MDCCCLXIV

THE ARTIZAN

ENGINEERING JOURNAL

VOL 2 THIRD SERIES

VOL XXII OLD SERIES

STEAM NAVIGATION SHIP BUILDING AND THE APPLICATION OF CHEMISTRY TO THE INDUSTRIAL ARTS

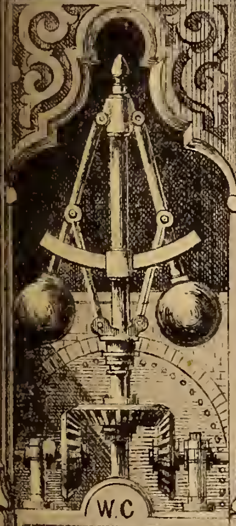
A MONTHLY RECORD of the PROGRESS of CIVIL and MECHANICAL ENGINEERING

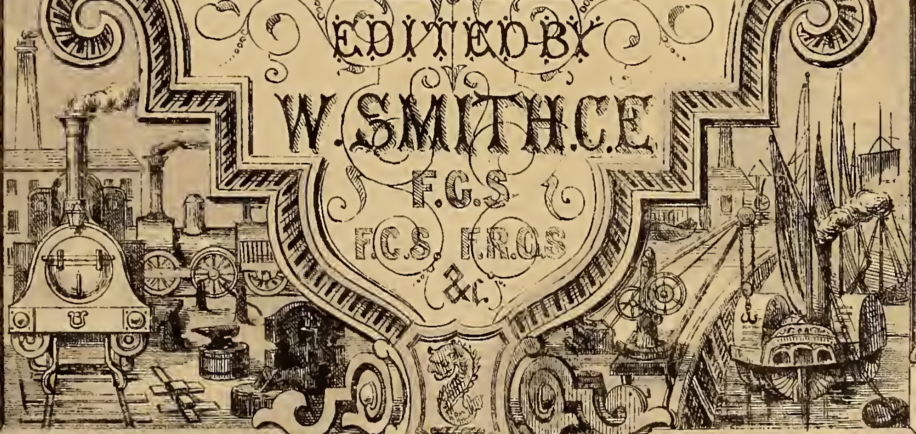
ESTABLISHED 1843.

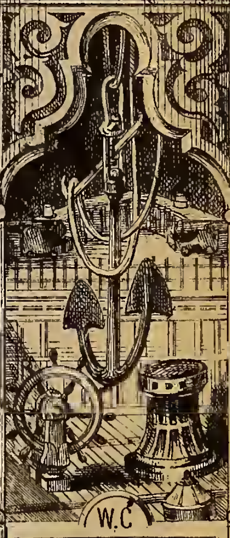
EDITED BY W. SMITH C.E. F.C.S. F.G.S. F.R.G.S &c.

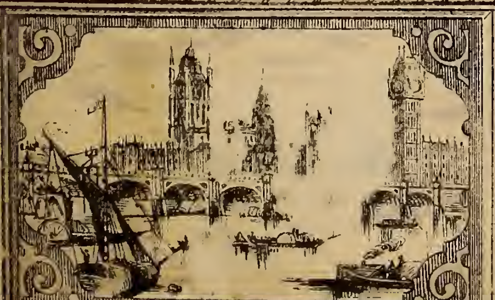
PUBLISHING OFFICES

W.C 19 SALISBURY ST STRAND, LONDON. W.C

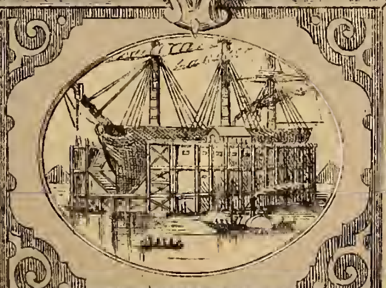








WESTMINSTER BRIDGE



RENNIE'S FLOATING DOCK

CHARING CROSS R.Y BRIDGE

THE ARTIZAN:

A Monthly Record of the Progress

OF

CIVIL AND MECHANICAL ENGINEERING,

SHIPBUILDING, STEAM NAVIGATION, THE APPLICATION OF CHEMISTRY TO THE INDUSTRIAL ARTS, &c.

EDITED BY WM. SMITH, C.E.

F.G.S., F.C.S., F.R.G.S., &c.

VOL. II.
THIRD SERIES.

VOL. XXII.
FROM THE COMMENCEMENT.

London:

PUBLISHED AT THE OFFICE OF THE "ARTIZAN" JOURNAL,
19, SALISBURY STREET, STRAND, W.C.

1864.

LONDON:

PRINTED BY GEORGE WYBURN MATTHEWS,

AT THE "SCIENTIFIC PRESS," 3, RUSSELL COURT, BRYDGES STREET, COVENT GARDEN, W.C.

INDEX TO VOL. XXII.

THE ARTIZAN JOURNAL, 1864.

A.

Abel, Prof., on the chemical history and application of gun-cotton, 151
Aberdare, explosion at, 70
Abstract log of the Great Eastern, 4
Adams, W. B., on the impedimental friction between wheel tyres and rails, 111
Alkaloids in medical extracts, assay of, 263
Allan's automatic smoke consuming apparatus, 90
Amalgamator, improved, 210
Amber, 188
Anchors, Rodgers's, testing of, 141
Ancient mining machinery, 263
Anthracite as a locomotive fuel, 262
Apparatus for weighing the photometric standard candle, 185
Applications for letters patent, 24, 48, 72, 96, 120, 144, 168, 192, 216, 240, 264, 288
Appointment of naval engineers, 18, 43, 67, 91, 116, 141, 164, 188, 212, 236, 260, 284
Armour plating, protecting, 211
Armour plated ships of war, 20, 42, 50, 51, 67, 141, 164, 188, 211, 235, 260, 284
Armour plates, testing of, 18, 19, 43, 68, 92, 116, 165, 189, 212
Artesian wells in France, 140
——— G. R. Burnett, on the machinery employed in sinking on the continent, 155
Articles from cast iron, manufacture of, 263
Ashton Vale Iron Company, 139
Assurance, steam boiler, 51
Atmospheric hammer, 283
Atomicities, on the classification of the elements in relation to their, by Prof. Williamson, 179
Auriferous silver out of ores, extraction of, 238
Austrian armour plated frigates, 51

B.

Balance sheet, the, 115
Banks, reclamation of, 59, 82
Bath, meeting of the British Association—The President's address, 243
Belfast, shipbuilding in, 44
Bessemer's steel spherical shots, 44
Bill of exchange, 259
Bills passed, 163, 188, 210
Binnacle lamp, a new species of, 236
Birckel, J. J., a critical and historical review of locomotive engineering, 1
Birckel, J. J., a historical and descriptive sketch of the Mersey docks and harbour, 145, 168, 193, 217, 241, 265
——— on the Bradfield reservoir, 73
——— on Norton's pump, 78
Blake's stone crushing machine, 80
Blasting and electricity, 119
Blast furnace in Cashmere, 40
Bodies, on the resistance to, passing through water, 82
Boiler explosions, on, 51
——— 22, 70, 93, 94, 118, 143, 166, 208, 214, 238
——— Manchester Association for the Prevention of, 22, 45, 69, 93, 117, 166, 190, 207, 233, 278
Bolts and nuts, 269
Bombay, drainage of, 17
Books received, 16, 114, 137, 162, 187, 209, 281
Bradfield reservoir, 105, 113, 143
——— inundation, results of the inquest, 86
——— reservoir, report on the embankment of, and on the probable causes which led to its failure, 73
Bray's Traction Engine Company, 17
Breech-loading rifles, 236
Bricks, patent stone, 283
Bridges:
  Blackfriars railway bridge, 262
  Burton-on-Trent, new bridge at, 191
  Clifton suspension bridge, 70, 286
  Forth, proposed railway at, 286
  Holborn valley viaduct, 262
  Hutchison Town bridge, 238
  Korono, bridge over the Niemen, at, 262
  Chatham, new pier at, 166
  Mersey, new bridge over the, 166
  Niagara river, bridging, 143
  Portsmouth, new floating bridge at, 281
  Rhyl, new iron, 94
  Seine, great bridge over the, 286
  Suspension bridge, proposed American, 70
  Tay, proposed railway, 286
  Trent, the bridge over the, 143
  Tyne, proposed new, 286
  Walton-on-Thames, new at, 94
  Wandsworth to Fulham, proposed new, 46
  Bridging Niagara river, 46
Brighton, the junction road out-fall at, 163
British Association for the Advancement of Science—papers read, 225, 248
British empire, statistics of the, 67
Brixton, fall of nineteen arches at, 67
Broadside *v.* Turret System, 279
Building materials, exhibition of, 140
——— preservation of, 89
Burnett, G. R., on the machinery employed in sinking Artesian wells on the continent, 155

C.

Cable, new Atlantic, 131
Cails's shot and shell, 97
Cameron's patent double cam lever punching machine, 256
Cameron, P., on iron, its molecular structure, 12
Canadian packets, 17
Carbonisation of illuminating gas, 239
Castings, large, 17, 286
Chain cables, on the testing of, 127, 137
Channel Fleet trials, 260
Chemical Society, 85, 199
Chemistry:
  Alcohols, on the oxidation of, 23
  Aldihydes, a new method of producing, 215
  Aluminium, 239, 287
  ——— manufacture of, 23
  Aniline, manufacture of, 239
  ——— green, preparation, 191
  ——— in varnishes, 239
  Anti-corrosive mixture, 263
  Assay of the alkaloids in medical extracts, 263
  Azuline, its optical properties, 23
  Beer, on the adulteration of, with picrotoxine, 95
  Blowpipe, reaction of copper, 71
  Brine, utilisation of, 191
  Bromide of potassium, 287
  Chlorine, manufacture of, 239
  Chrome green, another, 23
  Decomposition of iodine of mercury, 95
  ——— of water, 143
  Dulos's processes of engraving, 143
  Electric fertiliser, 47
  Electro chemical engraving on metal, 95
  Elementary body, new, 23
  Green colour, on the preparation of, without arsenic, 119
  Gun cotton, 215
  Hydrocarbon in coal tar, 287
  Indestructible writing, 287

Chemistry:
Iodide of ammonium, on the preparation of, 119
—— of mercury, 95
Iodine, new uses of, 95
Manganiferous cast iron, the influence of fluxes on the composition of, 71
Minium of iron, 287
Morphia salts of commerce, 263
Nature printing from steel, 167
New elementary body, 23
New quadruple salt, 239
Nitro benzol in oil of bitter almonds, 287
Oxalic acid, on the purification of, 71
Oxygen gas, novel mode of producing, 95
Oxygen, on the difference between active and ordinary, 263
Photography, discovery in, 47
Pig-iron, chemical constitution of, 215
Protecting iron and steel from oxidation, 95
Respiration of fruits, 215
———— of plants, experiments on, 167
Rubidium, 287
Saffron, 287
Silver, some curious properties of oxide of, 143
Stannic and tungstic acids, 47
Soda in coal gas, 239
Suboxide of copper, preparation of, 143
Sulphuric acid, on the purification of, 95
Wasium, on the non-existence of, as a single body, 23
Claudet, A., on photo-sculpture, 226
Clyde, steam shipbuilding on the, 20, 44, 68, 92, 116, 141, 165, 189, 212, 236, 261, 285

Coal:
Brazilian, 46, 118
Burning furnaces for, 257
China, 238
England, fields of, 47
How it may have been formed, 263
Indian, 22, 119, 167, 286
London coal trade, 17, 210, 235, 283
North country and Welsh steam, 90
Mont Cenis tunnel, coal in, 118
Scotland, in, 215
South Wales coal in the London market, 359
Sumatra, discovery of coal at, 167
Coal tar, researches on the colouring matter derived from, 205
Coating ships with glass, 67
Coinage, the gold, silver, and bronze, of 1863, 227
——— in Spain, 211
Coffer dams for cleaning and examining the bottom of ships, 140
Combination ship, 166
Companies, new act on public, 17
Composite ships, 182
Connecting ship, 212
Copper, 167
——— paint, pure, 71
Coppering iron ships, 284
Correspondence, 39, 65, 87, 113, 137, 256, 281
Correspondents, notices to, 16, 40, 114, 138, 162, 187, 209, 234, 258, 281

Cotton:
Culture in Italy, 18
——— in France, 80
Gun, the chemical history and application of, 151
Gun and gunpowder, 187
Gun, 259
Crane, Taylor and Co.'s patent locomotive steam, 255
Cranks, proportions of, 282
Crewe, water for, 191
Cross, J., on the structure of locomotive engines for ascending steep inclines, 111
Croydon water supply, 239
Crucibles: manufacture of plumbago, 210
Crushing machinery, 283
Currency, 112
——— and Mint, Hong-Kong, 27
Cut-off valves, 149
Cyclops Works, 90

D.

Dalifol's improvements in the manufacture of malleable iron, 97
Die engraving, sinking, and multiplying; by J. Newton, 172
Docks:
Birkenhead, accident to, 94
Cardiff, 262
Commercial and Grand Surrey and Canal Bill, 41
Devonport and Keyham Dock Accommodation, 238
Galway Harbour, 118
Leith Docks, extension of, 46, 70
Metallic piers and piles, 214
Milford Haven, 94
Spezzia, dockworks at, 46
Sunderland, 286
Tod and M'Gregor's new slip dock, 238
Wear Dock, 46
Woolwich Dockyard, accident at, 41
Doors, new method of hanging, 210
Double cylinder expansion engines, 50, 77, 175
Drainage, London main, 139

E.

East coast between the Thames and the Wash estuaries, 59
East Indian Irrigation and Canal Company, 159
Economy in the use of steam, 223, 254, 271
Edwards, T. J., tunnel under the river Mersey, 29
Electrical force, the laws and operations of, 273
Engineering, locomotive; a critical and historical review of, 1
———— notes from New Zealand, 3
———— progress in Italy, 16
Engineers, appointment of naval, 18, 43, 67, 91, 116, 141, 164, 188, 212, 236, 260, 284
Engine, Lenoir's gas, 239, 287
Engines, Wymer's high and low pressure, 148, 217
———, double cylinder expansion, 50, 77, 175
Enormous casting, 210
Erosion of lead by insects, 235
Exhibition, industrial, in London, 259
———— in Copenhagen, 283
———— in Dublin, 163
————, permanent, of Paris, 66
Expenditure, naval, 115
Explosions, see boiler explosions

F.

Factory Acts, extension of the, 115, 198
——— inspection report, 115
Factories, electric light in, 259
Fairbairn, H., on wrought iron girders, 84
———— and Co., large machinery and iron business of, 41
Faulkner's electric pit signals, 119
Fire insurance, 210
Flowers, preserving, 283
Fortifications, 140
Fouling of iron ships, 211
France, export of iron to, 17
Frankland, E., on recent chemical researches in the Royal Institution, 177
———— on the glacial epoch, 62
Franklin Institute, Journal of the, 223, 254, 271
French submarine boat, 67
Frigates, Austrian armour-plated, 51
Furnaces for coal burning, improvements in, 257
Fylde Waterworks Company, 239

G.

Galway and America, mail service between, 90

Gas:
Analysis, on a new method of, 199
Apparatus, new lighting, 263
Bowditch's new hydrocarbon light, 263
Carbonisation of illuminating, 239
Carburetting apparatus, 23
Coke burning, utilisation of gas in, 90
Coke ovens in connection with, 70
Companies, position of, 119
Continental Union Gas Company, 119
Dividends and prices, 23, 70, 94, 119, 143, 167, 191, 215, 239, 288
Explosion of, 41, 70, 263, 287
Gosport, supply to, 70
Lenoir gas engine, 239, 287
London Companies, 143
Meter Company limited, 287
Moscow, gas in, 287
Paris, lamp-posts at, 23
Producing material, 23
Utilising company, gas products, 191
Water and gas, 167
Water gas, 119
Wilna, lighting of the town of, 167
Girders, wrought iron, by W. Fairbairn, 84
Glacial epoch, on the, 62
Glass, on the processes and mechanical appliance in the manufacture of polished sheet, 196
—— sheathing for ships' bottoms, 115
Gold, Australian, 46
—— in New Zealand, 46
——, silver, and bronze coinage, of 1863, 227
—— from Australian colonies and New Zealand, 167
Graham, T., on the properties of silicic acid and other analogous colloidal substances, 204
Great Eastern, abstract log of the, 4, 41, 67
———— as a screw steamer only, 116
Greece, mineral wealth of, 47
Greene, D. M., on economy in the use of steam, 223, 254, 271

Guns:
Armstrong, 19, 116, 141
Blakeley, 19, 212
Casting of monster, 91
French rifled, 44
Hutchison's, 261
Mackay's, 116, 141, 165
New proposed system of carrying heavy, 92
Palliser's, 212
Rodman's, 284
Trial of new, 92
Gunpowder, explosion of, at Liverpool, 41
———— regulations for the carriage of, 284
———— substitute for, 41
Gutta percha, substitute for, 67

H.

Hammer, monster steam, 115
———— atmospheric, 283
Harris, Sir W. Snow, on the laws and operations of electrical force, 273
Hemming, S. C., improvements in the permanent way of railways, 280
Heppel, J. M., on the reclamation of banks, 57, 83
Historical and descriptive sketch of the Mersey Docks and Harbour, 145, 168, 193, 217, 241, 266
Hoist, steam, new direct-acting, 139
Hofman, A. W., researches on the colouring matter derived from coal tar, 205
Holborn valley improvement, 238
Hong Kong, currency of, 27
Hughes, Sam., C.E., F.G.S., supply of public lamps by meter, 6

Humber Iron Works and Shipbuilding Company, 117
Hydraulic machines, testing of, 141
——— pressure, welding by, 235, 258
——— shears and punch, description of, 32

I.

Improvements in vessels of war, 65
India, finance account of, 210
India-rubber packing for stuffing boxes, 235
——— telegraph wires, 180
Indian ink, substitute for, 259
Industrial Exhibition in London, 259
Ireland, supply of fuel, 46
Iron:
Alloy for, 286
Architecture, 139
Cast, improved, 139
Cementation of, 286
Compressed oxygen, combustion of iron in, 85
Crystallised, 143
Enormous casting, 286
France, export of, to, 17
Iron and steel spars, 227
Lake Superior, 286
Malleable, Dalifol's improvements in the manufacture of, 97
Masts of Achilles, 42
Molecular structure and its magnetic distribution, 12
New South Wales, 67
Ships, on the construction of, by J. Vernon, 98
——— fouling of, 211
Tubes, lining of, 90
Water, preservation of iron in, 286
Institution of Civil Engineers, 11, 55, 82, 110, 126, 155, 181, 276
——— Mechanical Engineers, 32, 61, 78, 98, 196
——— Naval Architects, 111, 126
Italy, engineering factories in, 42
——— notes on engineering progress in, 16

K.

Jack, J., effect of surface condensers on steam boilers, 61
Jordan, J., on composite ships, 182

L.

Lamp, improved Davy, 41
Lamps, supply of public, by meter, by S. Hughes, 6
Land, steam cultivation of, 17
Large castings, 17
Lawrie, J. G., on iron and steel spars, 227
Lead, erosion of, by insects, 235
Legal Decisions:
Bovill *v.* Hardley and others, 114
Colliery case, 209
Composition deeds, 238
Contributories, liability of, 282
Cubitt *v.* Smith, 282
Curtis *v.* Platt, 40
Edwards *v.* De Normandy, 56
Foxwell *v.* Bostock, 89
Gas companies, assessment of, 258
Gerish *v.* Bernstingl, 17
Gwynne *v.* the Metropolitan Board of Works, 187
Hill *v.* the Midland Railway Company, 114
Holdsworth *v.* M'Crae, 162
Horton *v.* Mahon, 162
Lancaster, Mr., on stone crushing machines, 80
Lane *v.* Sterne, 17
Oxlade *v.* the North-Eastern Railway Company, 40
Parson *v.* Edwards, 40
Rating Railways, 282
Roberts and Another *v.* Rose, 139

Legal Decisions:
Roberts *v.* Rose, 209
Staffordshire and Worcestershire Canal Company *v.* the Birmingham Canal Company, 282
Submarine Telegraph Company *v.* Dickson, 40
Thames Embankment in Chancery—Macey *v.* Metropolitan Board of Works, 89
Trotman *v.* Wood, 17, 139
Wynne and another *v.* Allsopp and others, 56
Lenoir gas engine—steam superseded, 239
Light, a new, 163
Lighthouse at Arranmore, 18
Lignite in Turkey, 287
Liverpool Polytechnic Society, 157
——— town improvements, 259
Lloyd, W., description of the Santiago and Valparaiso Railway, 110
Locomotion by hydraulic power, 45
Locomotive engineering, a critical and historical review of, 1
Locomotives, water for, 68
——— for sharp curves, 39, 87
——— new French, 93
London Association of Foremen Engineers, 12, 74, 83, 156
——— coal trade, 17
——— mortality, 90
Lumley, H., on the steering of ships, 112

M.

Madras Irrigation and Canal Company, 133
Magnesium light, the new, 234
Magnetic ether, 41
——— experiment, on a, by J. Tyndall, 176
Mallet's construction of piers and walls, 94
Malta Harbour and our ironclads, 70
Manchester Association for the Prevention of Steam Boiler Explosions, 20, 44, 68, 92, 116, 141, 165, 189, 212, 233, 278
Mann, G. O., on the decay of materials in tropical climates, and the methods employed for arresting it, 277
Marks, fraudulent trade, 41
Martin's patent anchor, 18
M'Lean, J. R., 55
Measure, the units of, 225
Mersey docks and harbour, a historical and descriptive sketch of, by J. J. Birckel, 145, 168, 193, 217, 241, 266
———, trial course for steamers in the, 237
——— proposed tunnel under the river, 29
Metallic alloy, 117
——— piers and piles, 214
Metric system, the, 210
Meynard's steam and fluid regulator, 163
Middle level, 90
Milford, fortifications at, 259
——— Haven, 94
Military engineering, 18, 43, 91
Mines:
Accidents to, 46
Blasting by electricity, 94
Copper, British and American, 115
Hoist, hook for, 46
Mineral wealth of Italy, 71
Richest mine in the world, 94
Ventilation of, 23
Mining machinery, ancient, 293
Molecular vortices, the hypothesis of, 87
Mont Cenis locomotive, 69
——— tunnel, state of works and description of the machinery employed, 60
Moon, photographs of the, 18

N.

National Gallery, 140
Naval engineers, appointment of, 18, 43, 67, 91, 116, 141, 164, 188, 212, 236, 266, 284
——— ordnance, 49

Navies:
American, 49, 73, 87
Austrian, 51
English, state of the, 42, 67
French, 236
Russian, 18, 141, 188, 235
Spanish, 188, 284
Newspaper statistics, 66
Newton, J., die engraving, sinking, and multiplying, 172
New Zealand, engineering notes from, 3
——— Exhibition, 90
Norton's V Pump, description of, 78
Notices to Correspondents, 16, 40, 114, 138, 162, 187, 209, 234, 258
Nottingham, opening of the new reservoir, 140
Novel steam engine, 211
Nystrom, J. W., on the parabolic construction of ships, 160

O.

Obituary notices, 88
Oporto, international exhibition at, 259
Ordnance, naval, 49
Organic bodies, on the synthesis of, 105
Ostend, steamers to, 57
Oxygen, on the difference between active and ordinary, 263

P.

Pacific steam route to Australia, 117
Paget, F. A., on the testing of chain cables, 127
Paper, consumption of, 41
Parabolic construction of ships, 160
Paris, public works in, 163
Patents, application for letters, 24, 48, 67, 72, 96, 120, 144, 168, 192, 216, 240, 264, 288
——— on the value of, 7
——— office returns, 115
Peacock, C.E., R.A., on the pressure of steam at high temperature, 2, 25
People, chief occupation of, 66
Petroleum, 18
——— oils, 210
——— production and application of, 259
Phipps, G. H., on the resistances of bodies passing through water, 82
Photographs of the moon, 18
Photometric standard candle, apparatus for weighing the, 185
Photo-sculpture, 226
Picking's, J., improvements in refrigerators, 161
Pier, new, for St. Ives, 94
Pilkington, jun., R., on polished sheet glass, 196
Plumb-line, deflection at Cowhythe, 259
Pneumatic Despatch Company, 140
Polytechnic Society, 29
Pontoons, raising a wreck by, 212
Portsmouth, experiments at, 91
Post-office savings bank, 139
Premiums awarded at the Institution of Civil Engineers, 276
President's address, British Association, 243
Prestwick, J., on the Quarternary flint implements of Abbeville, Amiens, &c., 107
Printing machine, reacting, 18
Progress of the post, 259
Pumps, description of Norton's V, 78
Punching machine, Cameron's double cam lever, 257

Q.

Quarries of Paris, 71
Quarries, slate, in Canada, 22
Quarternary flint implements of Abbeville, Amiens, &c., 107
Quicksilver, how to test it and detect adulteration, 238

R.

Railways:
Accidents on, 21, 22, 45, 69, 93, 117, 142, 166, 190, 214, 238, 262, 285
American, 21
Atlantic to the Pacific, 21
Atmospheric, Harding's improvements in, 78
Andes, railway across the, 142
Axles, 142
Bills, 68
Brake, new, 21
Capital expended on, 68
Charing Cross, 21, 45
Clarke's safety railway brake, 21
Clauses, railway, 21
Clearing house, 237, 261
Directors, 45
Duties, 45
Fares, 45
Festiniog, 21
French, 93, 142, 262
Great Eastern, 117
Great Eastern and Lancashire and Yorkshire, 261
Great Western, 45
Hammersmith and City, 166
Indian, 21, 213, 237
Ireland and Scotland, 117
Irish, 237
Iron for, 45
Lamp, new, 21
Liverpool, in the vicinity of, 213
London and North-Western, 142, 285
London, Chatham, and Dover, 142, 285
Madrid and Irun, 69
Mexican, 213
Mineral traffic of, 213
Mont Cenis, tramway on, 45
Natal, 262
New Zealand, 117
——— opening of first in, 68
Permanent way of, 280
Plan for, between England and France, 66
Revenue, 190, 213
Schemes, 189
Signals, 285
South American, 110
Spanish, 261
Steel rails, 69
United Kingdom traffic receipts, 45
Venezuela, 189
West Norfolk Junction, 261
Wheels for the prevention of accidents, 117
Working expenses, 214
Rankine, J. M'Q., on some of the strains of ships, 225
——— on units of measures, 225
——— summary of the properties of certain stream lines, 248
Raschette blast furnace, 188
Reclamation banks, on the closing of, 59
Redmond, J. B., on the east coast between the Thames and the Wash estuaries, 59
Refrigerators, Picking's improvements in, 161
Reserve, Royal, 188
Reservoir, the Bradfield, by J. J. Birckel, 73
———, 105

Reviews and Notices of New Books:
Annuaire des Ecoles d'Arts et Métiers, 209
Binns, W. S.—Orthographic Projection and Isometrical Drawing, 137
Borghi, Luigi.—La Stella d'Italia, 280
Burgh, N. P.—Pocket-book of Practical Rules for the Proportions of Modern Engines and Boilers for Land and Marine Purposes, 234
——— Practical Illustrations of Modern Land and Marine Engines, 209
——— A Treatise on Sugar Machinery 40

Reviews and Notices of New Books:
Burnell, G. R.'s, The Builders' and Contractors' Price-book, 40
Clark, D. K.—The Exhibited Machinery of 1862, 135
Dickerson, E. N.—The Navy of the United States, 88
Dowling, C. H.—Metric Tables, 186
Fairbairn, W.—On the Application of Cast and Wrought Iron to Building Purposes, 209
Gillmore, Q. A.—A Practical Treatise on Limes, Hydraulic Cements, and Mortars, 40
Green, H., translated by.—The Sewing Machine, 88
Halstead, Rear-Admiral.—England's Navy Unarmed, 209
Haskoll, W. D.—Engineers, Mining Surveyors, and Contractors' Field-book for Expediting Field Work Operations, 162
——— Examples of Bridge and Viaduct Construction of Masonry, Timber, and Iron, 258
Haslett, C. and Huckley, C.—Mechanics, Machinists, and Engineers' Practical Book of Reference, 88
Haupt, H.—Military Bridges, 162
Humber, W.—A Record of the Progress of Modern Engineering, 40
Hunt, R.—Memoirs of the Distinguished Men of Science of Great Britain living in the Years 1807-8, 162
Jeays, J.—The Orthogonal System of Hand-railing, with Practical Illustrations of the Construction of Stairs, 161
Lockwood & Co.—Packing Case Tables, 258
Main, T. J.—The Indicator and Dynamometer, 88
Molesworth, G. L.—Pocket-book of Useful Formulæ and Memoranda, 39
Naylor, W.—On the Bradfield Reservoir, 137
Niccol, R.—Sugar and Sugar Refining, 186
Normand, J. A.—Mémoire sur l'Application de l'Algébre aux Calculs des Bâtiments de Mer, 114
Paris, le Contre Amiral.—Supplément de l'Art Naval à l'Exposition Universelle de 1862, 186
Stephenson, Sir Macdonald.—Railways in China, 162
Stevenson, D.—Lighthouses, 280
Stevenson, T.—The Design and Construction of Harbours, 136
Taylor, J.—The Battle of the Standards, 88
Templeton, W.—The Operative Mechanics' Workshop Companion, 161
Tennent, Sir J. E.—The Story of the Guns, 40
Timbs, J.—The Year-book of Facts in Science and Art, 88
Williams, C. W.—On the Steam-generating Power of Marine and Locomotive Boilers, 257
Roberts, Richard, tribute to the late, 112
Robertsfors Ironworks Company, 187
Robinson, T. R., on a new mercurial gasometer and air pump, 181
Rodgers's anchors, testing of, 141
Rouen Art Union, 283
Royal Geographical Society, 12
Royal Institution of Great Britain, 62, 105, 151, 176
Royal School of Naval Architecture, 284
Royal Society, 8, 84, 181, 204, 273
Russell, J. Scott, on the present state of the question at issue between modern guns and iron-coated ships, 111
Russell, W. J., and A. W. Williamson, on gas analysis, 199

S.

Sang, E.—Nature and management of the sefinet equation for determining the form of a ship's hull, 53
Santiago and Valparaiso Railway, on the, by W. Lloyd, 110
Saturated steam, table of the properties of, 120
Subaqueous navigation, 211
Schiele, C., on turbine water wheels, 157
Scott, Capt. R. A. E., on ironclads, 112
Scottish Shipbuilders' Association, 12, 182, 227
Screw threads and nuts, 269
Shields, colliery explosion near, 239
Shipbuilding, innovation in, 19
——— on the Tyne, 213
——— at Waterford, 20
Ship's hull, form of, &c., by E. Lang, 53
Ships composite, 182
—— fouling of, 211
—— iron, on the construction of, 98

Ships (Steam, Mercantile), Launch of:
Abigail, 261
Alexandra, 285
Bebside, 213
Bolivian, 92
Calabar, 68
Cunard steamer, a, 189
Eastern Province, 68
Ellen, 44
Evelyn Mary, 142
Granadian, 68
Gunga, 261
Impératrice Eugénie, 117
Lady Young, 92
Norfolk, 285
Norseman, 285
Rosina, 261
Sir Herbert Maddock, 285
Venetia, 142

Ships, Steam (Mercantile), Trials of:
Anne Liffey, 285
Atlanta, double screw, 92
Avalon, 165
Baroda, 92, 117
Brittany, 285
Cawarra, 212
Colonel Lamb, 237
Cuba, 285
Damietta, 212
Far East, 44
Foam, 236
Golconda, 43
Kinshaw, 20
Knight Templar, 237
Lafayette, 212
London, 237
Mula, 212
Tasmania, 141
Urgent, 212
Venetia, 189
Washington, 117
Yacht for the Sultan, 237
Yuef Tze Tne, 68

Ships Steam (Naval), Dimensions of:
Achilles, 42
Ammonoosuc (American), 87
Dictator (American), 44
Ferdinand Max, 51
Hapsburg, 51
Lord Warden, 42
Nishaminny (American), 87
Wampanoag (American), 87

Ships, Steam (Naval), Launches of
Achilles, 20
Dictator (American), 44
Ferdinand Max, 51
Favourite, 189
Hapsburg, 51
John David, 20
Lord Clyde, 261
Minotaur, 20

SHIPS, STEAM (NAVAL), LAUNCHES OF:
Osman Ghazof (Turkish), 237
Prince Albert, 142
Royal Alfred, 261
Zealous, 93

SHIPS (STEAM), TRIALS OF NAVAL:
Achilles, 115
Alberta, 42
Aurora, 116
Broneuocetz (Russian), 260
Bulldog, 115
Caledonia, 67, 140
Channel Fleet, 260
Clio, 211
Conqueror, 18
Dauntless, 188
Double screw launch, 116, 211
Duncan, 67
Enterprise, 163
Experiment, 90
Fawn, trial of, 42
Fawn, 188
Hector, 19, 91
Irresistible, 116
Linnet, 235
Lyra, 42
New Zealand, gunboat, 18
Ocean, 164
Orontes, 236
Ranger, 90
Recruit, 43
Research, 67
Royal Sovereign, 141, 164, 235
Salamis, 164
Serpent, 260
Sharpshooter, 164
Tamar, 20
Tennessee (Confederate), 235
Victoria, 236, 284
Warrior, 18, 284
Wasp, 18
Winnebago (United States), 20
Wizard, 42

Shoeburyness, experiments at, 91, 165
Silicic acid, on the properties of, 204
Slates, dressing of, 18
Small arms manufactory at Birmingham, 19
Smith's, G. P., radial traversing carriage worked by Taylor's patent steam crab, 121
Smoke, injurious effect of, on stone and vegetation, 36
Society of Arts, 36, 127

SOCIETIES, PROCEEDINGS OF:
Chemical Society, 85, 199
Institution of Civil Engineers, 11, 55, 82, 110, 126, 155, 181, 276
Institution of Mechanical Engineers, 32, 61, 78, 98, 196
Institution of Naval Architects, 111, 126
Liverpool Polytechnic Society, 157
London Association of Foremen Engineers, 12, 76, 83, 156
Polytechnic Society, 29
Royal Geographical Society, 12
Royal Institution of Great Britain, 62, 105, 151, 176

SOCIETIES, PROCEEDINGS OF:
Royal Society, 8, 84, 181, 204, 273
Society of Arts, 36, 127
Scottish Shipbuilding Association, 12, 182, 227

Sopwith, jun., T., on Mont Cenis Tunnel, 60
Southampton, shipbuilding at, 212
South Wales ports, shipbuilding at the, 141, 46
Sowerby Bridge waterworks, 239
Spanners, self acting, 134
Spars, iron and steel, 227
Spinning machinery, on the construction of, 33
Staleybridge waterworks, 239
Steam fire engines, trial of, 41, 67

STEAM:
On the pressure of at high temperatures, 2, 25
Boilers, prevention of incrustation of, 67
Boilers, effect of surface condenser on, 61
Boiler assurance, 51
——— explosions, see boilers
Clyde, shipbuilding on the, 20, 44, 68, 92, 116, 141, 165, 189, 212, 236, 261, 285
Cultivation of land, 17, 211
Economy in the use of, 223, 254, 271
Locomotive crane, 255
Pressure of, at high temperatures, 66
Saturated, Prof. Zeuner's table on, 122, 272

Stream lines, summary of the properties of certain, 248
Steel and iron, treatment of, 18
Steering of ships, on the, by H. Lumley, 112
Stone-crushing machine, 258
Stone, induration of, 67
Strains of ships, 225
St. Petersburgh a port, 258
Submarine boat, French, 67
Subways, 90
Supply of public lamps by meter. By S. Hughes, C.E., F.G.S., 6
Surface condensers, the effect of, on steam boilers, 61
Surveyor, election of, to the Birkenhead Commissioners, 41
Symonds, Captain T. E., on Broadside *v.* Turret System, 279
———————, on the Construction and Propulsion of Twin Screw Vessels, 126

T.

Tangye, James, description of hydraulic shears and punch, 32
Tavistock Ironworks and Steel Ordnance Company, 139
Taylor & Co.'s patent locomotive steam crane, 255
Taylor's patent steam crab, 120
Tees breakwater, 22

TELEGRAPHIC ENGINEERING:
Atlantic telegraph, 117, 285
Bonelli's typo-electric, 45
Canadian Telegraph Company, 142
Electric and International Telegraph, 68
Europe and America, 93
Indian telegraphs, 21, 45, 93
New Atlantic cable, 139
New South Wales, 189
Persian Gulf telegraph, 68, 117
Russian telegraphs, 68

TELEGRAPHIC ENGINEERING:
South Australia, 261
Submarine telegraphs, 45, 92
Telegraph progress, 44
Typo-telegraphy, 21
World, telegraph round the, 189

Templeton, W., fund for the widow and family of the late, 256
Testing of armour plates, 18, 19, 43, 68, 92, 116, 141, 165, 189, 212
Thames embankment, 41
Thames Iron Works and Shipbuilding Company, 90
Traction engine, Bray's, 17
Trade of north-eastern ports, 41
Thermograph, a new, 235
Traffic of the streets of London, 41
Trent, new bridge over the, 143
Tunnel under Lake Michigan, 41
——— Mont Cenis, 60
——— under river Mersey, 29
Turbine water-wheels. By C. Schiele, 157
Twin screw vessels, on. By Capt. T. E. Symonds, 126
Tyndall, J., on a magnetic experiment, 176
Tyne, shipbuilding on the, 213

U.

United States ironclads, 211
——————— ironclad steam floating batteries or monitors, 49, 73
Units of measure, 225
Use of steam, economy in the, 223

V.

Valve, improved steam, 235
Value of small patents, 7
Valves cut off, 149
Ventilating apparatus, 235
Vernon, J., on the construction of iron ships, 98
Voelcker, Dr. A., on the injurious effect of smoke on certain building stones and vegetation, 36

W.

Wanklyn, J. A., on the synthesis of organic bodies, 105
Waterford, steamship building at, 20
Water, consumption of, 215
——— supply of Paris, 70, 119
Waterworks in Burnley, 167
————— in Dublin, 119
Weights and measures, new proposed, 90
Weild, William, on spinning machinery, 33
Welding by hydraulic pressure, 234, 258
Wells at Pompeii, 259
Williamson, A. W., on the classification of the elements in relation to their atomicities, 179
Winan's cigar steamer, 117, 120
Wood, preservation of, 259
Wool spinning, 235
Worcester Engine Works Company, 139
Wymer's high and low pressure engines, 148, 217

Y.

Yacht, ancient, 67

Z.

Zeuner's, Professor, table of the properties of saturated steam, 122, 272

LIST OF PLATES.

257. Illustrative of Mr. W. Weild's paper "On the Construction of Drawing Rollers for Spinning Machinery."
258. United States' Iron-clad Steam Floating Batteries or "Monitors."
259. United States' Steam Floating Batteries.
260. The Construction of Iron Ships.
261. Bird's-eye view of Smith's Radial Traversing Carriage, as adopted for the Spithead Forts.
262. Radial Traversing Carriage worked by Taylor's Patent Steam Crab.
263. Wymer's 250 Horse-power Inverted Cylinder Engines.
264. Outline of the Estuary of the River Mersey in the 17th Century.
265. Plan of the Mersey Docks and Harbour.
266. High and Low Water Features of the River Mersey.
267. The Mersey Estuary, from the Surveys of Capt. H. M. Denham, R.N., F.R.S.
268. 1,000 Horse-power Horizontal Engine, designed by Mr. F. W. Wymer, Newcastle-on-Tyne.
269. Mersey Docks and Harbour.
270. Mersey Docks and Harbour.
271. Gauge for Screw Cutting Tools.

LOCOMOTIVE ENGINEERING

GREAT EASTERN RAILWAY COMPY'S GOODS ENGINE.

FIG. 1.

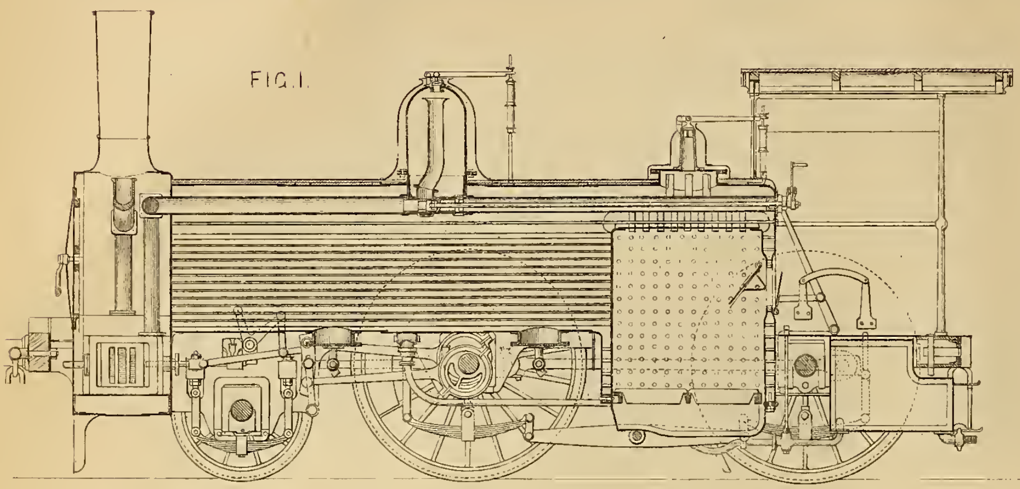


FIG. 3.

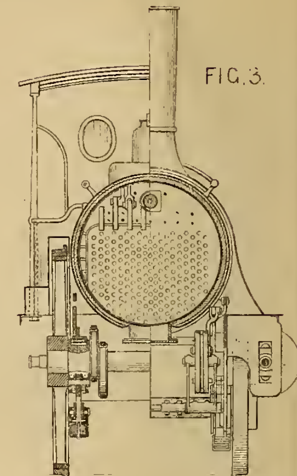


FIG. 2.

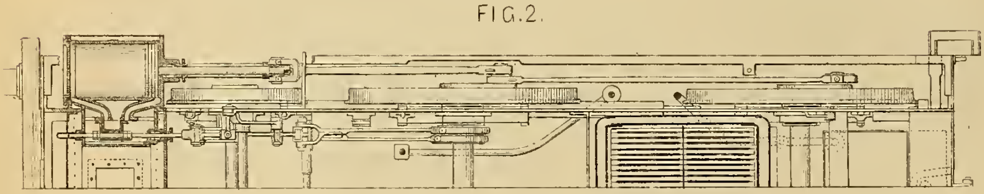
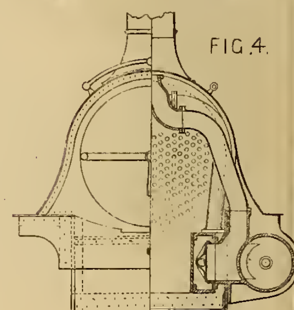


FIG. 4.



EXPRESS ENGINE FOR THE M. S. & L. RAILWAY.

FIG. 5.

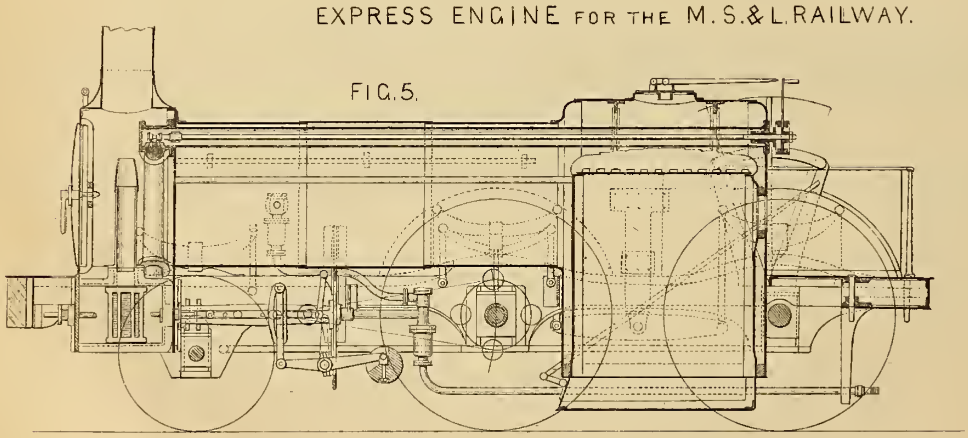


FIG. 7.

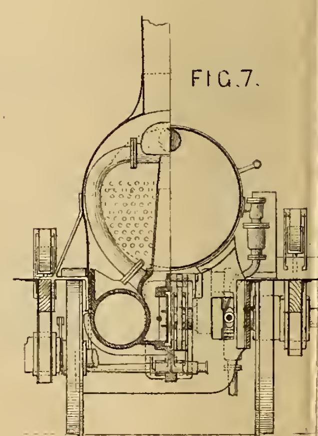


FIG. 6.

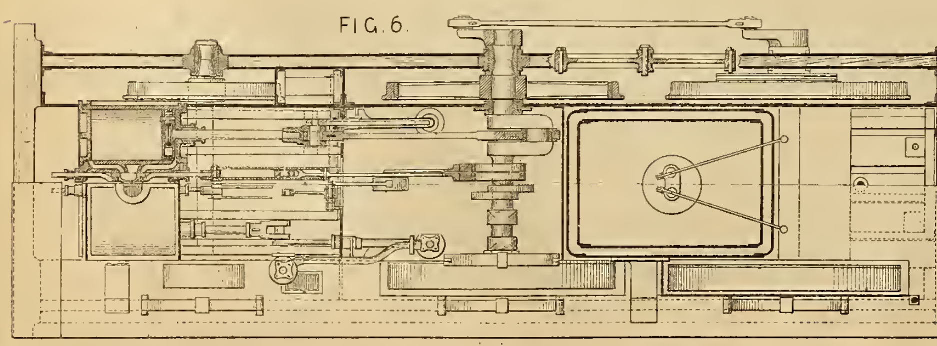
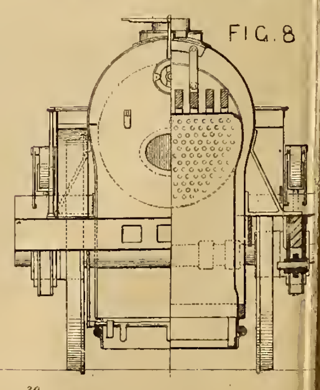
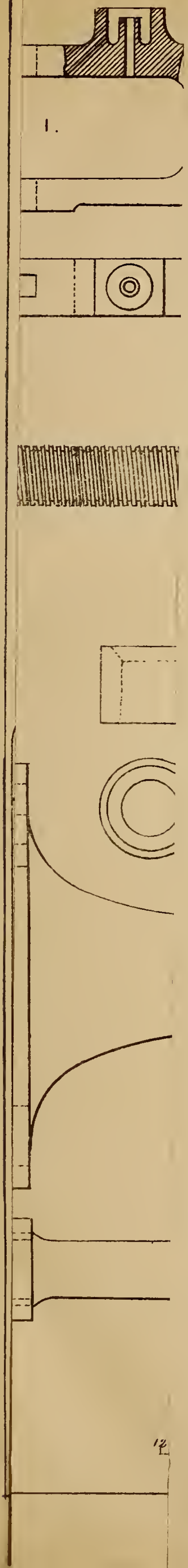


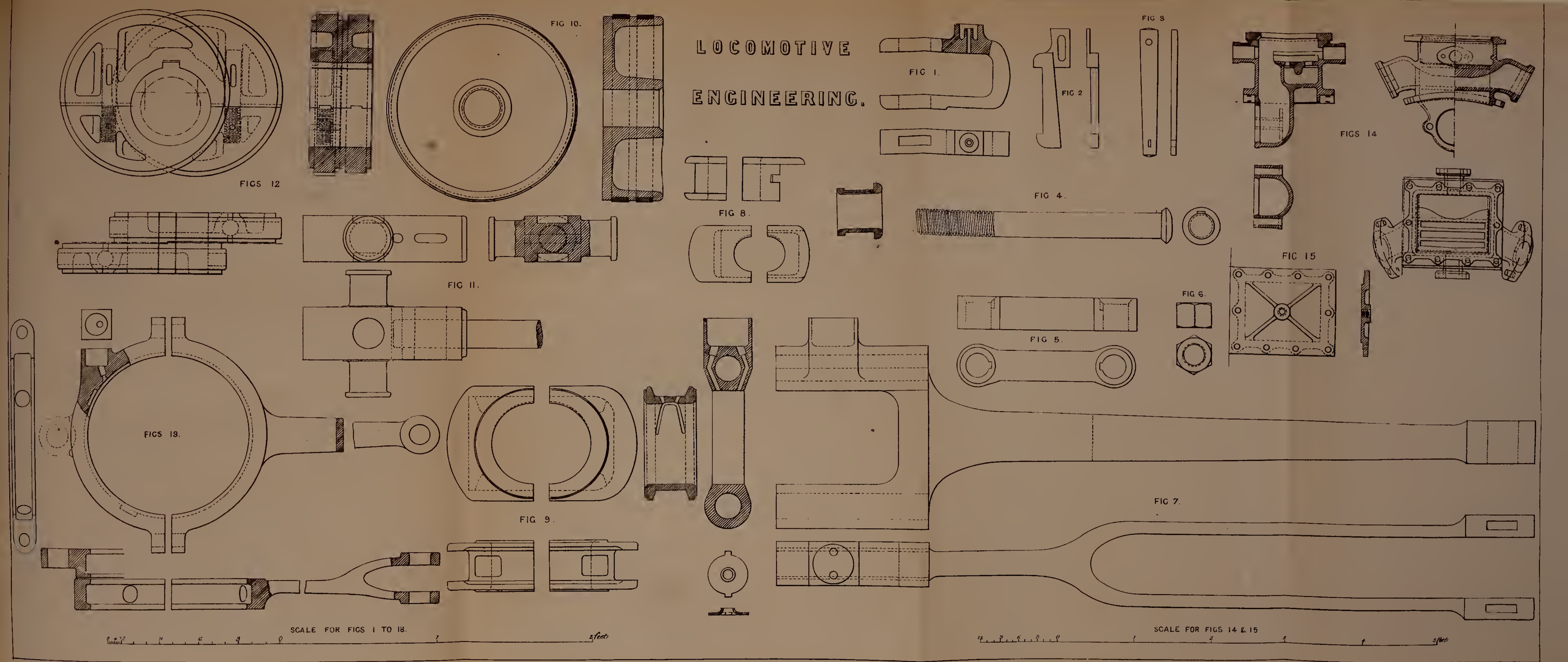
FIG. 8.



12 6 0 1 2 3 4 5 10 15 20 Feet

W. Smith, C.E. direx


1.



W Smith C E direx

THE ARTIZAN.

No. 13.—Vol. 2.—Third Series.

JANUARY 1st, 1864.

A CRITICAL AND HISTORICAL REVIEW OF LOCOMOTIVE ENGINEERING.

By J. J. Birckel.

Postscript to the Papers of January and of October, 1863.

In our paper of January, 1863, we have shown that the total quantity of heat contained in a given weight of steam remains practically constant for all pressures, and we have therefrom drawn the conclusion that steam engines become more economical gradually as the working pressure of the steam increased, without, however, giving any numerical value to the rate of increase of economy with pressure. As this subject cannot be too forcibly impressed upon the minds of our readers, having been enabled to supply this interesting item of information by means of the data on the density of steam furnished to us by Drs. Rankine and Fairbairn, which we have embodied into our paper of October, 1863, we now give the same in the table below, and the mode of obtaining it is as follows:—

1st. For a given volume of steam the quantity of energy created varies directly as the pressure; 2nd. The total heat contained in two equal volumes of steam of different pressures is proportional exactly to their respective densities; and the economic value of the absolute energy contained in steam is, therefore, represented by *the ratio* of the rates of increase of density with pressure.

With regard to the useful work obtained from steam, it may be assumed in this comparison that in non-condensing engines all steam admits of being expanded down to the pressure of the atmosphere, and that the whole of the energy contained in atmospheric steam is absorbed by the resistance of the atmosphere; upon these assumptions the quantity of work in foot-pounds contained in a pound weight of steam at any pressure is expressed by the formula (1),

$$p\,v\left(1 + \text{hyp. log. }\frac{v_1}{v}\right) - p_1\,v_1 \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where p and v stand for the pressure per square foot, and the volume in cubic feet of a pound of steam of any density, and p_1 and v_1 for the pressure and volume of a pound of steam at the atmospheric pressure; the results of this formula are contained in column 5 of the table below, and the rate of increase of efficiency or the economic value of the steam is contained in column 6.

Table of Economic Value of Steam at Different Pressures.

Absolute Pressure in lbs.	Rate of Increase of Pressure.	Rate of Increase of Density.	Economic Value of Energy Created.	Non-Condensing Engines. Work in One Pound of Steam.	Non-Condensing Engines. Economic Value of Steam.	Condensing Engines. Work in One Pound of Steam.	Condensing Engines. Economic Value of Steam.	Rate of Economy, Non-Condensing Engines being taken as Unit.
15	1,000	1,000	1,000	0	$\frac{1}{\infty}$	48,296	0,54	∞
25	1,666	1,620	1,027	29,357	0,72	78,122	0,87	2,6
30	2,000	1,917	1,042	40,392	1,00	89,450	1,00	2,2
40	2,666	2,533	1,053	57,674	1,42	106,914	1,19	1,8
50	3,333	3,090	1,078	72,634	1,79	122,424	1,36	1,6
60	4,000	3,682	1,086	84,065	2,08	133,990	1,49	1,5
70	4,666	4,274	1,091	93,922	2,32	143,901	1,60	1,5
80	5,333	4,830	1,104	103,518	2,56	153,731	1,71	1,4
90	6,000	5,402	1,110	111,140	2,75	—	—	—
100	6,666	5,992	1,112	117,746	2,91	—	—	—
110	7,333	6,574	1,117	124,066	3,07	—	—	—
120	8,000	7,154	1,122	129,733	3,21	—	—	—
130	8,666	7,660	1,130	136,226	3,37	—	—	—
140	9,333	8,202	1,137	141,742	3,50	—	—	—
150	10,000	8,731	1,143	147,004	3,63	—	—	—
160	10,666	9,282	1,148	151,662	3,75	—	—	—
165	11,000	9,553	1,151	153,902	3,81	—	—	—

It may not be without interest, while engaged upon this subject, to extend this comparison to condensing engines, in the case of which it may be assumed that steam at any pressure can be expanded down to 5lbs. below the atmosphere, and that one-half the energy contained in steam at the atmospheric pressure is absorbed by the air pump and the condenser, though in practice it never reaches that amount; the work in foot pounds contained in a pound of steam, at any pressure, is then expressed by formula (2),

$$p\,v\left(1 + \text{hyp. log. }\frac{v_2}{v}\right) - \frac{1}{2}\,p_1\,v_1 \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where $p\ v$ and $p_1\ v_1$ retain their former meaning, and v_2 represents the volume in cubic feet of a pound of steam at 5lbs. below the atmospheric pressure; the results of this formula are contained in column 7, and the rate of economy in column 8. For the information of those who are of opinion that the condenser has become a useless adjunct to the steam engine, and should be consigned to its grave alongside the immortal Watt, its father, we have given in column 9 the relative economy of condensing engines compared with non-condensing engines, and we shall be much surprised if these figures do not cure those who labour under the above-named delusion, should they cast their eyes upon these pages; these figures, in fact, show that at any pressure condensing engines must be more economical than non-condensing engines, working at the same pressure; and from columns 7 and 5, it may be seen that steam at 55lbs. effective pressure in condensing engines yields as high a duty as steam at 150lbs. effective pressure in non-condensing engines; and this, no doubt, does account for the fact that the locomotive engine, though working

under great disadvantages, such as high velocities of piston, contracted and difficult steam passages, cooling influence of the atmosphere, and others, works nearly as economically now as the marine engine or even the stationary engine.

It is to be regretted, however, that superficial observers, instead of tracing this latter fact to its real source, have drawn from it the conclusion that very high speeds of piston are not detrimental to the economic working of the steam engine, and are advocating high piston speeds in consequence; although all observations with the indicator show, and scientific reasoning sustains the fact, that steam working under such conditions looses a great per centage of its energy through wire drawing and friction.

We are fully aware that the quantities of work given in columns 5 and 7, are not actually realised, but the ratios given in columns 6 and 8 are not on that account considerably altered. We know also that steam is not expanded down to the limits we have assumed, but the assumption which we have worked upon only shows in a less favourable light the one fact which we have desired to impress upon the minds of our readers, viz., that the steam engine becomes enonomical in proportion as high pressure steam is used.

ON THE PRESSURE OF STEAM AT HIGH TEMPERATURES.

By R. A. Peacock, C.E.

Some years ago the writer had occasion to attempt to calculate the probable pressure of steam at the highest known temperatures, and found, amongst other things, that between the pressures of 25lb. per square inch and 300lb. to the square inch, the latter being the highest pressure to which reliable experiments had been carried, the law of increase was approximately as follows:—

1. The *temperature* of high pressure steam of, say, 25lb. to the square inch and upwards, increases as the $4\frac{1}{2}$ *root* of the pressure.

2. Conversely the *pressure* of steam of, say, 25lb. to the square inch and upwards, increases as the $4\frac{1}{2}$ *power* of the temperature.

3. At lower pressures than about 25lb. per square inch, a different law prevails.

It may, perhaps, be of interest to some to see the calculations by this formula placed side by side with the results of some of the best known experiments and formulæ. And on a future occasion the working formula, which is very simple and short, will also be given.

The following table gives a copy of the "more trustworthy of Arago and Dulong's experiments after all necessary corrections," copied from "A Treatise on Heat," by the Rev. R. V. Dixon, A.M., Dublin, 1849, p. 173, and copied by him from "Ann. de Chim. et de Phys.," tome xliii, p. 108, reduced, however, from Cent. degrees to Fahr., and from elastic force in atmospheres of 0·76″ to pressure in pounds per square inch by the present writer, an atmosphere being taken at 14·7lb. It will be seen that the formula does not agree with M. M. Arago and Dulong's experiments, but that it does agree nearly with other well-known experiments specified afterwards.

The American Commissioners' experiments, which are not now given, differ as much from the formula as M. M. Arago and Dulong's, but in a different way.

M. M. Arago and Dulong's Experiments.

Pressure.	Temperature Fahrenheit Observed.	Temperature Fahrenheit Calculated.	Differences.
lbs. per sq. in.	Deg.	Deg.	+
31·458	254·66	252·83	1·83
42·196	271·94	269·88	2·06
67·23	301·46	299·31	2·15
95·516	326·12	323·61	2·51
108·4198	335·30	332·84	2·46
170·99	371·30	368·31	2·99
252·619	404·24	401·68	2·56
254·089	405·32	402·20	3·12
272.008	410·90	408·33	2·57
316·858	425·12	422·42	2·70
351·8298	435·47	432·36	3·11

The following are the experiments of Dr. Wm. Fairbairn, F.R.S., given at p. 313 of "Useful Information for Engineers," second series. The formula, it will be seen, never differs as much as half a degree Fahr. from experiment; and the calculations being sometimes less and sometimes greater than the corresponding experiments, indicate that the experiments are averaged by the formula, and some of the differences are quite insignificant.

Pressure.	Temperature Fahrenheit Observed.	Temperature Fahrenheit Calculated.	Differences.
lbs. per sq. in.	Deg.	Deg.	
26·5	242·90	243·37	—·47
27·4	244·82	245·19	—·37
27·6	245·22	245·59	—·37
33·1	255·50	255·71	—·21
37·8	263·14	263·36	—·22
40·3	267·21	267·14	+·07
41·7	269·20	269·17	+·03
45·7	274·76	274·70	+·06
49·4	279·42	279·50	—·08
51·7	282·58	282·34	+·24
55·9	287·25	287·28	—·03
56·7	288·25	288·20	+·05
60·6	292·53	292·48	+·05

The following are M. Regnault's experiments from 23lb. to the square inch up to 300lb. to the square inch, from which the formula never differs as much as three-quarters of a degree Fahr., and at 300lb. pressure it very nearly coincides with experiment.

Regnault's experiments, as now given, are copied from Dr. W. Fairbairn's "Mills and Millwork," vol. 1, p. 202, obtained from the tables of M. Regnault, by interpolation and reduction to English measures.

Pressure.	Temperature Fahrenheit Observed.	Temperature Fahrenheit Calculated.	Differences.
lbs. per sq. in.	Deg.	Deg.	
23	235·43	235·83	—·40
24	237·75	238·07	—·32
25	240·	240·24	—·24
26	242·16	242·34	—·18
27	244·16	244·39	—·13
28	246·32	246·37	—·05
29	248·30	248·30	equal
30	250·23	250·17	+·06
31	252·09	252·01	+·08
32	253·94	253·81	+·13
33	255·70	255·53	+·17
34	257·47	257·23	+·24
35	259·15	258·90	+·25
36	260·83	260·52	+·31
37	262·44	262·11	+·33
38	264·04	263·67	+·37
39	265·58	265·20	+·38
40	267·12	266·70	+·42
41	268·60	268·16	+·44
42	270·07	269·60	+·47
43	271·50	271·02	+·48
44	272·91	272·40	+·51
45	274·30	273·77	+·53
46	275·65	275·11	+·54

Pressure.	Temperature Fahrenheit Observed.	Temperature Fahrenheit Calculated.	Differences.
lbs. per sq. in.	Deg.	Deg.	
47	276·99	276·42	+·57
48	278·30	277·72	+·58
49	279·59	279·	+·59
50	280·85	280·25	+·60
51	282·09	281·49	+·60
52	283·32	282·70	+·62
53	284·53	283·90	+·63
54	285·73	285·08	+·65
55	286·90	286·25	+·65
56	288·05	287·40	+·65
57	289·19	288·53	+·66
58	290·31	289·65	+·66
59	291·42	290·75	+·67
60	292·51	291·84	+·67
65	297·77	297·08	+·69
70	302·71	302·01	+·70
75	307·38	306·67	+·71
80	311·83	311·10	+.73
85	316·	315·32	+·68
90	320·03	319·35	+·68
95	323·87	323·22	+·65
100	327·56	326·92	+·64
105	331·10	330·49	+·61
110	334·51	333·92	+·59
115	337·84	337·24	+·60
120	340·99	340·44	+·55
125	344·06	343·54	+·52
130	347·05	346·55	+·50
135	349·93	349·47	+·46
140	352·76	352·30	+·46
145	355·6	355·06	+·54
150	358·3	357·75	+·55
160	363·4	362·91	+·49
170	368·2	367·84	+·36
180	372·9	372·54	+·36
190	377·5	377·04	+·46
200	381·8	381·37	+·43
210	386·	385·52	+·48
220	389·9	389·52	+·38
230	393·8	393·39	+·41
240	397·5	397·13	+·37
250	401·1	400·75	+·35
260	404·5	404·26	+·24
270	407·9	407·07	+·23
280	411·2	410·97	+·23
290	414·4	414·19	+·21
300	417·5	417·32	+·18

It will be observed that the discrepancies between the formula and M. Regnault's table are not confirmed by Dr. Fairnbairn's experiments. For example, with the pressure 56lb. in Regnault's table, we have a difference between that table and the formula of + ·65, whereas between Fairbairn's table for the pressure 56·7lb. and the formula, we have a difference of only +·05, and the like is observable with respect to Fairbairn's pressure of 60·6lb., and Regnault's pressure of 60lb.; so that it is probable the apparent discrepancy which gradually increases up to +·73 and then diminishes again between the formula and Regnault's table, does not really exist.

The following table is given in THE ARTIZAN for October, 1863, p. 219, the third and fourth columns being calculated by the present writer as before.

Pressure.	Mr. Birckel's Temperature.	Temperature Calculated.	Differences.
lbs. per sq. in.	Deg.	Deg.	
24·54	239	239·255	−·255
28·83	248	247·976	+·024
33·71	257	256·745	−·205
39·25	266	265·574	+·426
45·49	275	274·426	+.574
52·52	284	283·33	+·67
60·40	293	292·27	+·73
69·21	302	301·25	+·75
79·03	311	310·264	+·736
89·86	320	319·24	+·76
101·90	329	328·285	+·715
115·10	338	337·3	+·7
129·80	347	346·43	+·57
145·80	356	355·5	+·5
163·30	365	364·564	+·436
182·40	374	373·63	+·37
203·3	383	382·75	+·25
225·9	392	391·82	+·18

This table, by Mr. J. J. Birckel, agrees very nearly with M. Regnault's.

In the November number of THE ARTIZAN, Mr. Macquorn Rankine, F.R.S., publishes a paper "On the Expansive Energy of Heated Water," in which he gives a table, which we quote from; and which, in its first part, consists of some of the identical figures just given under the name of Mr. J. J. Birckel.

The following is Mr. Macquorn Rankine's table—the last two columns being added in the usual manner by the present writer.

Initial Absolute Pressure.	Initial Temperature Fahrenheit.	Initial Temperature Fahrenheit Calculated.	Differences.
lbs. per sq. in.	Deg.	Deg.	
28·83	248	247·976	+·024
52·52	284	283·33	+·67
89·86	320	319·24	+·76
145·8	356	355·5	+·5
225·9	392	391·82	+·18
336·3	428	428·05	−·05
	about 2360	729,632lbs. or 325.7 tons.	

(*To be continued.*)

ENGINEERING NOTES FROM NEW ZEALAND.—We learn from the latest files received from New Zealand that a system of works for the supply of the city of Otago with water, are to be forthwith constructed by means of a subscribed capital, the interest being guaranteed by the Government. The necessary guarantee ordinance has been passed, and the prospectus of the company—registered under the Joint-Stock Companies' Act of New Zealand—has been issued, the directory including the names of many of the most influential citizens. Another guarantee ordinance has been passed, authorising the raising of a loan of £50,000 for the construction at Port Chalmers of graving docks on Clarke's hydraulic principle, and insuring interest at the rate of six per cent. for ten years to investors. The capital for this important work is forthcoming, and nothing is waited for but the completion of the necessary legal formalities to commence operations. The explorations of Dr. Hector have resulted in the discovery of a fine port and navigable river leading to an inland lake on the western coast of the Middle Island. A connecting line of railway from an available port on the west to the capital of the province on the east will probably be one of the most valuable fruits of Dr. Hector's labours.

ABSTRACT OF THE ENGINEER'S LOG OF THE STEAMSHIP "GREAT EASTERN,"

Name of Port.	Date of Departure.	Date of Arrival.	Immersion on Departure.				Mean Immersion on Departure.		Immersion on Arrival.				Mean Immersion on Arrival.		Time between Ports.	
			For.		Aft.				For.		Aft.					
			ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	Days.	hrs.
Southampton to New York	June 17, 1860	June 28, 1860	21	2	26	1	23	7½	...	...			...		11	4
New York to Milford	Aug. 17, 1860	Aug. 27, 1860	...	...			...		...	...			...		9	4
Milford to New York	May 2, 1861	May 12, 1861	23	9	26	4	25	0½	19	6	25	0	22	3	9	18
New York to Liverpool	May 25, 1861	June 4, 1861	22	9	25	5	24	1	19	4	24	0½	21	9	9	3
Liverpool to Quebec	June 27, 1861	July 7, 1861	23	4	28	1	25	8½	21	6	25	6	23	6	8	22
Quebec to Liverpool	Aug. 6, 1861	Aug. 16, 1861	24	6	26	6	25	6	21	0	23	0	22	0	8	22
Milford to New York	May 2, 1862	May 17, 1862	23	3	26	8	24	11½	19	6	25	0	22	3	9	18
New York to Liverpool	June 1, 1862	June 11, 1862	25	0	25	6	25	3	21	0	23	0	22	0	9	11
Liverpool to New York	July 1, 1862	July 12, 1862	23	6	26	0	24	9	20	9	25	4	23	1½	9	11
New York to Liverpool	July 27, 1862	Aug 6, 1862	26	3	29	9	28	0	24	6	25	6	25	0	10	0
Liverpool to New York	Aug. 17, 1862	Aug 27, 1862	26	0	26	0	26	0	22	0	25	0	23	6	10	13
New York to Liverpool	Jan. 5, 1863	Jan. 17, 1863	25	2	29	11	27	6½	21	3	28	6	24	10½	11	3
Liverpool to New York	May 16, 1863	May 28, 1863	23	11	26	2	25	0½	21	10	23	8	22	9	11	1
New York to Liverpool	June 7, 1863	June 18, 1863	27	0	28	1	27	6½	23	6	25	10	24	8	10	6
Liverpool to New York	June 30, 1863	July 12, 1863	23	9	27	6	25	7½	21	2	25	0	23	1	11	16
New York to Liverpool	July 22, 1863	Aug. 2, 1863	25	9	28	0	26	10½	23	0	25	9	24	4½	10	23
Liverpool to New York	Aug. 12, 1863	Aug. 25, 1863	23	9	26	1	24	11	20	4	25	6	23	0	11	21
New York to Liverpool	Sept. 8, 1863	Sept. 20, 1863	27	3	28	1	27	8	23	0	26	6	24	9	11	3
Total Quantities	... ...	... ...	...	...			...		...	...			...		184	0
Average per Voyage	... ...	... ...	24	5⅝	27	0¾	25	9¼	21	5½	25	1⅝	23	3⅝	10	5½

VOYAGES TO NEW YORK, AND BACK TO LIVERPOOL.

Paddle Engines.						Screw Engines.										
Total Revolutions.	Revolutions per Minute.	Steam Gauge.	Fuel used per Day.	Knots run by the Paddles.	Slip per cent. of Paddles.	Total Revolutions.	Revolutions per Minute.	Steam Gauge.	Knots run by the Screw.	Slip per cent. of Screw.	Fuel used per Day.	Total Fuel Expended.	Knots run by the Ship.	Average Knots run per Hour.	Knots per Hour per Ton of Coal.	
		Lbs.	Tons.	Knots.				lbs.	Knots.		Tons.	Tons.	Knots.	Knots.		
164,326	10	19½	110	3,964	19	532,034	34·7	17½	3,901	17·7	153	2,877	3,211	13	·895	
146,226	10·9	22½	122	3,765	18·8	508,494	38·8	19	3,670	16·5	193	2,744	3,061	13·5	·895	
133,000	9·48	21½	114	3,477	15	525,276	37·5	17¾	3,742	21	158	2,717	3,017	13·75	·9	
137,430	10·4	21½	143	3,456	12·5	520,407	38·5	18½	3,646	18·7	178	2,893	3,083	14	·936	
131,219	10·2	22	143	3,260	16	472,340	36·7	19	3,409	22·5	182	2,931	2,803	13·33	1·04	
135,910	10·57	21	172	3,359	14·6	480,892	37·5	19	3,428	16·3	207	3,384	2,869	13·37	1·17	
147,850	10·5	21½	119	3,564	12·6	511,976	36	18	3,690	20·3	152	2,715	3,076	13·5	·882	
149,310	11	20½	137	3,883	16·5	515,570	37·4	16¾	3,832	15·4	170	2,904	3,442	14·25	·892	
153,180	11·25	21½	139	3,782	19	508,230	37·3	16½	3,670	16·6	168	2,926	3,059	13·48	·956	
139,228	9·7	21½	139	3,478	10·8	498,185	35	17½	3,663	14·05	165	3,051	3,128	13·04	·973	
150,845	10	21	140	3,736	17·63	521,715	34·5	17	3,755	18	161	3,243	3,077	12·16	1·05	
148,158	9·3	20	137	3,695	16·7	521,940	32·6	17¼	3,759	18	158	3,281	3,078	11·52	1·07	Ship's bottom damaged.
149,038	9·35	21	126	3,704	16·25	564,900	35·5	17½	4,021	22·8	178	3,324	3,101	11·7	1·08	One paddle cylinder disconnected on account of the weigh-shaft of port forward cylinder being carried away.
141,711	9·4	21	122	3,366	8·02	521,170	35·3	17½	3,595	14·7	178	3,228	3,066	12·47	1·05	
162,001	10·2	21	114	3,888	25	561,518	35·16	17	4,006	27·2	178	3,303	2,914	10·4	1·13	
139,175	9·22	21	111	3,499	13·8	527,540	33·75	16	3,801	23·6	173	3,120	3,075	11·65	1·02	
153,556	9	18	105	3,856	18·41	573,906	33·57	16½	4,180	24·7	170	3,263	3,146	11·54	1·04	Paddle wheel disabled
149,419	9·32	20½	168	3,615	12·8	511,270	32	17	3,727	16·28	167	3,267	3,204	11·76	1·04	
2,631,591	...	...	...	65,297	...	9,377,363	...	...	67,595	...	...	55,171	55,276	...	...	
146,199	9·94	...	...	3,628	15·34	520,965	35·32	...	3,755	18·22	...	3,065	3,071	12·28	1	

SUPPLY OF PUBLIC LAMPS BY METER.

By Samuel Hughes, C.E., F.G.S.

In the origin of gas lighting before the introduction of the gas meter, the system of contract burning very commonly prevailed. The gas consumer instead of paying so much per 1000ft. for the gas which was actually used, was in the habit of paying a fixed sum per annum for each separate gas burner. Thus there was a fixed price per annum for each argand burner, each bats-wing, each fish-tail, and each single jet burner, it being understood that the burners were to be extinguished at a certain hour each night. We need scarcely point out how unsatisfactory this system must have been alike to the gas company and to the consumer. So glaring were its evils, so constant the misunderstandings which arose, and so frequent the complaints of the companies as to the quantity of gas which was burnt and not paid for, that the introduction of the meter, an instrument accurately recording the consumption, was hailed on both sides as a great boon.

In addition to the difficulty of checking, with any accuracy the *period* of burning under the contract system, there was another, and still more serious element of uncertainty, which arose from the varying pressure at which the gas was supplied from different gas works, and from the same works at different periods of the year and even during the course of the night. Of course the only mode of expressing the consumption of a burner with accuracy is to connect its consumption with pressure, in other words, to say the consumption is so many feet an hour at such and such pressure. If the pressure varies the consumption varies also, and hence the impossibility of estimating with anything like certainty the consumption of any burner during any given period, unless the pressure remains constant during the whole of that period. It was no wonder, therefore, that the introduction of the meter gave great satisfaction both to the consumer and the producer. The gas companies now usually insert in all their acts a distinct provision by which every consumer is required to burn by meter; and without a meter to register the consumption of the gas, he is not entitled to have a supply of gas at all.

So far as private consumers are concerned, from the least to the greatest, the meter system is now universal, and the old vicious, contract system only lingers in this country with regard to the public lamps, thus applying solely to a supply of gas which is paid for in most towns by a public lighting rate, charged alike on all the inhabitants. It may well be asked why should the contract system still prevail with regard to public lighting, and would it not be far better for all parties to abolish it for public lighting as well as for private, and allow the gas to be paid for by measure, instead of a vague and unsatisfactory method of guess-work. We have said the contract system, as applied to private lighting, was vicious and objectionable, owing to many causes; but when we examine its application to public lighting, the objections are even more serious than in the other case.

Under the old contracts, applied to private lighting, the consumer, at all events, had the privilege of lighting and extinguishing his own burners, and there was no interference by the officers of the gas company so long as he did not fraudulently substitute larger burners, or systematically keep his burners lighted during more hours than he contracted for. Is is far otherwise with the public lighting, however, because here the servants of the gas company as it were enter the premises, light *when* they please, adjust the taps of the burners *how* they please, and extinguish the lights *when* they please. How would a private consumer like this treatment in his own house, or with regard to his own burners? Yet this is the treatment with which every individual ratepayer puts up in his collective capacity as one of the public contributing to the lighting rate. We are not only under the control of the lamplighter as to the times of lighting and extinguishing, but as to quantity of gas which shall be doled out to us, a condition which the consumer, under the old contract system entirely escaped, because he could always turn on his taps how he pleased.

The contract system always viciously objectionable, is rendered ten times worse in the case of public lighting, by the fact that the services of lighting and extinguishing are performed by lamplighters employed by the gas companies. The perseverance in a system so wretchedly unfair to the public, can only be accounted for by the peculiar views which were entertained 50 years ago as to the mysteries of gas lighting, and by the inconceivable apathy of the public officers, who as a matter of dry routine, have prepared year after year the contracts for gas lighting in this country.

It is satisfactory to find, however, that a similar apathy has not been everywhere exhibited. The absurd injustice and want of all equity in the prevailing contract system has long been understood in many of the large manufacturing towns of Lancashire and Yorkshire. In nearly every Scotch town where meters are not used for the public lamps, the police light and extinguish; and as these are employed by the Police Commissioners or other local authority in each large town, the public is much better off than where this service is performed by the ordinary lamplighters. Nearly all over the Continent there is a distinct provision made against the caprice of the lamplighter in turning the tap so as to cut off the supply of gas according to his own fancy. In most continental towns, near the base of the lamp post, is fixed a regulating tap, which is adjusted by the municipal authority, and the gas company in concert, and this adjustment once made is beyond the control of the lamplighter, who only performs the simple duty of turning his own tap full on and full off, and thus one great source of fraud and uncertainty is avoided.

The street lamp governors used in many parts of London serve, to a certain extent, the same end, and take away all discretion on the part of the lamplighters. There are, however, many serious objections of another kind to the street governors, which it would occupy too much space to enter upon at present.

Although the system followed in the Scotch and continental towns is decidedly preferable to that in which the lamplighter exercises his own discretion, it leaves untouched the question of measurement. This, of course, can only be effected by the use of meters, a change which cannot be too highly recommended in the case of public lighting.

Rapid Increase of the Meter System for Public Lighting.

Although public attention has only, within the last year or two, been called to this subject, the system of meters for public lamps has already been adopted in a great many towns throughout Great Britain. Amongst these are Torquay, Worthing, Lincoln, Leicester, St. Ives, Bolton, Loughborough, Reading, Portsmouth, Dunfermline, Otley, Perth, Southam, Salisbury, Aylesbury, St. Neots, Liverpool, and Stirling. In addition to these, the subject is now engaging a serious attention, which will probably lead to the adoption of meters, in Birmingham, Baubury, Uxbridge, Worksop, Weston-super-Mare, and many other towns; while in the metropolis itself it is understood the Commissioners of Sewers for the City of London have made arrangements for attaching meters to about 1800 of their public lamps.

Average Meter Indication.

Considering that the public lamps of a town constitute a group of burners, which are all intended to consume the same quantity of gas per hour, it would evidently be a wasteful and unnecessary expense to attach a meter to every lamp; accordingly, we find that arrangements have usually been made between the Gas Company and the local authority, to be satisfied with an average meter indication—that is, for instance, with the indications of one meter to every twelfth, or twentieth lamp. Thus in Torquay, St. Ives, and Reading, every twelfth lamp-post has a meter attached to it; Aylesbury has 1 meter to 15 lamps; Otley, 1 to 18; Loughborough and Portsmouth, 1 to 20; Perth, 1 to 26; Southam, 1 to 38; Worthing, 1 to 70, and so on.

In three distinct cases Parliament has inserted special clauses in Gas Bills, relative to the proportion of meters. Thus in the Torquay and in

the Reading Gas Acts, the proportion was fixed at 1 meter to 12 lamps, and in the Portsmouth Gas Act, at 1 meter to 20 lamps.

RESULTS OF THE METER SYSTEM APPLIED TO PUBLIC LAMPS.

In every case the saving has been very great, the consumption per hour having been brought down from 5ft. an hour to an amount varying from 2ft. up to 4ft. an hour. The best results have been obtained at Reading, where the greatest pains have been taken to improve every part of the system. These improvements may be described as follows :—

1. A perfect means of adjusting all the lamps to an uniform pressure, so that all the lamps, whether metered or unmetered, shall consume the same quantity of gas.

2. A complete change of the old iron burners of small capacity, burning at a high pressure, for very large steatite burners consuming at a very low pressure.

3. Great economy in the hours and mode of lighting, from the local authority employing its own lamp-lighters, contracting the hours of burning, and employing the lighting-rod and lantern, instead of the old-fashioned ladders.

A valuable report from the Public Lights and Gas Committee at Reading, appeared in the *Sanitary Reporter,* of the 4th December last, setting forth the entire working of the meter system in Reading since its adoption on the 21st of May last.

Although there are other towns in which the system has been nearly as successful as at Reading, we prefer quoting the Reading case, as the details are here all given by the local authority itself, and are free from any suspicion which might attach to the statements of a partisan.

The following tabular view, and the observations which follow, are copied from the *Sanitary Reporter,* and are strictly founded on the report of the Reading Public Lights and Gas Committee, which is there printed at length :—

Period.	Hrs. from Sunset to Sunrise.	Quantity at 4ft. an hour.	Quantity at 5ft. an hour.	Quantity to be paid for by meter indication.	Saving as compared with 4ft. an hr.	Saving as compared with 5ft. an hr.
	hrs. m.	c. ft.	c. ft.	c. ft.	c. ft.	c. ft.
21st of May to 1st of July	313 40	1255	1568	940	315	628
Month of July...............	246 48	987	1234	243	744	991
„ August	294 21	1177	1471	369	808	1102
„ September	342 11	1369	1711	432	937	1279
	1197 00	4788	5984	1984	2804	4000

Thus the saving by the meter system, as compared with 4ft. an hour, has been 2804 feet per lamp in $3\frac{1}{3}$ months of the year, and the saving as compared with 5ft. an hour is actually 4000 feet per lamp.

The results of the meter system may be summed up under the following heads :—

1. The consumption by meter during 1197 hours of darkness has been 1984 feet per lamp, which is equal to 1·66ft. an hour.

2. Calculated at the same rate for the whole year, the consumption would be under 7000ft. per annum, as against 17,232, the consumption at 4ft. an hour, or against 21,540ft., the consumption at 5ft. an hour.

3. The lamps at Reading, in $3\frac{1}{3}$ months, have actually burnt 882 hours, the number of dark hours between sunset and sunrise having been 1197, the saving being chiefly due to the lighting and extinguishing being under the control of the local board.

4. The actual consumption of gas, as registered by the meters and agreed to by the company during these 882 hours, has been 1984 cubic feet, or at the rate of $2\frac{1}{4}$ft. an hour.

5. As the gas for public lamps is paid for at Reading by Act of Parliament at 3*s.* 7*d.* per 1000 feet, the actual money saving on each lamp in gas alone will amount, according to the experience of the meters, to 36*s.* 8*d.* per annum when compared with 4ft. an hour, and to 52*s.* 1*d.* per annum when compared with 5ft. an hour throughout the year.

6. In addition to this great saving in the cost of the gas for public lighting, the Local Board at Reading saves at least 5*s.* per lamp per annum by employing their own lamplighters, instead of allowing this service to be done by the gas company.

What has been done at Reading may be done everywhere else, and it is only apathy or ignorance which prevents the same improvements being made in every town throughout Great Britain, not excepting the metropolis.

[Our readers will find a great mass of additional information relative to public lighting, and the application of meters to public lamps, in a series of papers by Mr. Hughes, which appeared in the ARTIZAN for 1861 and 1862. Page 153 of the ARTIZAN for 1861 contains views of public lanterns, showing the mode of attaching meters to any existing lamp-post, although the mode of placing the meter in the interior of the lamp-post, as at Reading, is undoubtedly preferable. See also pages 128, 151, 180, and 200 of the ARTIZAN for 1861, and page 5 of the ARTIZAN for January, 1862. The *Sanitary Reporter,* a weekly paper, which commenced its career on the 3rd of July, 1863, contains a series of articles by Mr. Hughes on the same subject of public lighting, and the application of meters to public lamps. Mr. Hughes' papers have also attracted great attention in America, and have been republished in the *American Journal of Gas Lighting.*—ED. ARTIZAN.]

ON THE VALUE OF SMALL PATENTS.

The following very *apropos* remarks on the value of small patents appear in a recent issue of our transatlantic contemporary, the *Scientific American* :—

"There are a great many persons brought more or less in contact with the novelties and inventions of the day, who have heard the remark, "What a simple thing; anybody could have invented that!" Exactly; a truer criticism was never passed. It was not so much the nature of the invention, perhaps, as the shrewdness of the individual who introduced it and foresaw the advantages likely to accrue to him in a pecuniary point of view. If any one had told the inventor of the metallic-tipped shoe for children that his simple idea was worth hundreds of thousands of dollars, he would himself have thought the prophet a little too sanguine. Or to take a higher class of invention, no one could possibly foresee the tremendous trade which has sprung into existence from the sewing-machine; what an almost endless category of small articles or appliances, such as hemmers, fellers, quilters, button-hole machines, loop-checks, needles, shuttles, &c., have been, and are daily invented and brought out as indispensable additions to the greatest of all modern inventions! It is a mystery to us what becomes of all the sewing-machines; one firm, we are told, turns out 600 per week, and besides this company there are half a dozen others of nearly equal capacity urging their shops to the utmost.

"The office or object of the inventor is of course to make money, but if he achieve the double task of lightening labour and amassing wealth, his calling is so much the more to be honoured. There is no question but that those who improve the character of the simple articles in use in every household, or substitute newer and more ingenious appliances for doing hard work anywhere, have a sure prospect ahead of a most alluring nature. No investment is equal to a good invention of a popular kind, and none so quickly returns the discoverer an hundredfold for his outlay of time and study. Look about you, young men, and though you may not discover 'sermons in stone,' or 'books in the running brooks,' you will find 'good in everything,' and chances for wealth you little dreamed of. Of the inventions relating to kerosene lamps, it is calculated that upwards of 400 patents have been issued, and the number increases; this proves that there is or has been an immense field in that direction; which many parties to our knowledge have worked successfully and reaped fortunes thereby. What is true of this line of invention is equally so with reference to others; let those who wish to obtain a fair remuneration for their time and services turn their attention to the daily avocations of life, and improve the tools, instruments, utensils, and what not, employed in them, and they will have no reason to regret it; unless, indeed, after having once devoted time and attention to a good idea, they lay it on one side till a more convenient season, supposing that the world is going to wait their convenience for the improvement. Such a course is a mistaken one. Repeatedly we have heard parties say, 'What! is that patented? I have just such a model at home now;' and then when it is too late of course they go to work with intense zeal to bring out their invention. 'Delays are dangerous;' it is an old proverb, but a true one.

"Reader, if you have an idea respecting an invention do not hesitate, but bring it before the public at once. See to it, that in your case, at least, no halting, indecisive, half-way policy prevents you from obtaining a reward for your outlay of time and money."

THE ROYAL SOCIETY.

ANNUAL MEETING, Nov. 30th, 1863.

President's Address.

(Extract.)

Gentlemen,—When I had last the honour of addressing you at the Anniversary Meeting in 1862, I acquainted you that a communication had been received by your President and Council from the Duke of Newcastle, Her Majesty's principal Secretary of State for the Colonies, requesting the opinion of the Royal Society on the scientific importance of the results to be expected from the establishment of a telescope of great optical power at Melbourne, in the Colony of Victoria, for the observation of the nebulæ and multiple stars of the Southern Hemisphere. The communication was founded on a despatch from Sir Henry Barkly, K.C.B., Governor of Victoria, soliciting on his own part and on that of the visitors of the Melbourne Observatory, the opinion of the Royal Society on this subject, and also on the most suitable construction of the telescope, both as to the optical part and the mounting, its probable cost, and the time required for its completion. It had happened that in 1853 the Royal Society and the British Association had united in an earnest representation to Her Majesty's Government of the scientific importance of establishing in some convenient locality in Her Majesty's dominions, from whence the southern nebulæ and multiple stars could be observed, a telescope of the requisite optical power; and in a preparatory correspondence, which was printed at the time, and in which the principal persons interested in such researches had participated, the best form of telescope, its probable cost, and all particulars relating to it, had been largely discussed. The representation thus concurred in by the two principle scientific bodies of the United Kingdom was not successful in securing the desired object; but the correspondence then printed was still fitted to supply in great measure in 1862 the information on which the President and Council could ground their reply. The discussion in 1853 had terminated in the appointment of a committee, consisting of the Earl of Rosse, Dr. Robinson, and Messrs. Lassell and Warren de la Rue, to superintend the construction of the telescope, in the event of the recommendation of the two societies being favourably received. But as it was possible that the opinions previously entertained might have been in some degree modified, by subsequent consideration or by more recent experience, the correspondence with those gentlemen was re-opened, and their replies have formed a second correspondence, which, like the first, has been printed for the information of those Fellows of the Society who take a special interest in the subject. Availing themselves of these valuable communications, the President and Council replied to the Colonial Office by a report dated December 18, 1862. They have been since informed that copies of the report and of the correspondence have been sent to Melbourne for the information of the gentlemen with whom the proposition originated.

It is quite possible that the thoughtful discussions embodied in the correspondence referred to may be found to have a prospective value not limited to the occasion which has given rise to them. The considerations which apply to a telescope for the observation of the Southern Nebulæ at Melbourne are no less applicable to one which might be established on a site from whence a great part of the Southern Nebulæ could also be observed (as well as those of our own hemisphere), but enjoying the immense advantage conferred by elevation into the higher and less dense strata of the atmosphere. Such sites are to be found in the Nilgiris at elevations of several thousand feet, combining also convenient accessibility and proximity to the resources of civilized life. It may be hoped that at some not distant day the subject will receive the consideration which it deserves from those who are entrusted with the government of that now integral part of the British empire.

Having learnt that a series of pendulum experiments at the principal stations of the Great Russian Arc were in contemplation, I availed myself of an opportunity of informing M. Savitsch, by whom the operations were to be conducted, that the invariable pendulums which had been employed in the English experiments were now in the possession of the Royal Society, and, being unemployed, would, I was persuaded, be most readily lent by the society on an application to that effect being made. The constants of these instruments, including the co-efficient in the reduction to a vacuum, having been most carefully determined, they were ready, with the clocks and stands belonging to them, for immediate use, and would have the further advantage, that experiments made with them in Russia would be at once brought into direct connection with the British series extending from 79° 50′ N. to 62° 56′ S. latitude. The communication was most courteously received and replied to. It appeared, however, that a detached invariable pendulum had been already ordered by the Russian Government from M. Repsold, of Hamburg, shorter than the English pendulums for convenience in land transport, and with two knife-edges and two fixed lenses, symmetrical in size and shape but one light and the other heavy, and so arranged that the times of vibration should be the same on either knife-edge in air of the same temperature and density. M. Savitsch expressed his desire to bring this pendulum in the first instance to Kew, and to secure thereby the connection of his own with the English series, where also he would have the opportunity of testing the exactness of the correction for buoyancy by vibrating his pendulum on both its knife-edges in the vacuum-apparatus which is now established at Kew.

It is much to be desired that a similar series of pendulum experiments to those about to be undertaken in Russia should be made at the principal points of the Great Indian Arc; and the steps which are understood to be in progress in providing new instruments for the verification of the astronomical and geodesical operations of the trigonometrical survey of India, and to give them a still greater extension, would seem to present a most favourable opportunity for the combination of pendulum experiments. In such case the pendulums of the Royal Society might be made available with excellent effect.

The researches of Kirchhoff and Bunsen have rendered it in a high degree probable that we shall be able to obtain much insight into the chemical nature of the atmospheres of the brighter fixed stars, by observing the dark lines in their spectra and comparing them with the bright lines in the spectra of elementary, and perhaps also of compound, bodies in the state of incandescent gas or vapour. The interest of such an inquiry is obvious; but the difficulties involved in it are very great. The quantity of light coming from even such a star as Sirius is so small, that without the use of a powerful telescope the spectrum obtained would be too faint to bear sufficient enlargement to show properly the fixed lines. The apparent diurnal motion of the stars causes much embarrassment, unless the instrument be mounted equatoreally, and furnished with a clock movement. The control of the experiments on incandescent bodies requires a thorough knowledge of chemistry, so as to avoid being misled by impurities in the substances examined, and to be prepared to interpret decompositions or combinations which may take place under unusual circumstances, and which may be manifested only by their effects. Nor can the astronomical and physical parts of the inquiry be well dissociated, so as to be separately undertaken by different individuals; for the most elaborate drawings can hardly convey a faithful idea of the various aspects of the different dark and bright lines, which yet must be borne in mind in instituting a comparison in cases of apparent coincidence. It is fortunate, therefore, that the inquiry has been taken up by two gentlemen working in concert. In a short paper read to the society on the 26th of last February, and published in the proceedings, Mr. Huggins and Dr. Miller have described and figured the spectra of three of the brighter stars; and this part of the inquiry will doubtless be continued. In a paper since presented to the society, Mr. Huggins describes the means employed for practically determining with accuracy the positions of any stellar lines which may be observed, with reference to known points of the spectrum, and has given beautiful maps of the spectra of twenty-four of the elementary bodies under the action of the inductive discharge, reserving others for a future communication. When the inquiry is completed, it is possible that we may obtain an amount of knowledge, respecting the constitution of those distant heavenly bodies, of which we have at present little conception.

Professor Tyndall has given us the fourth of a series of papers upon the relation of gases and vapours to radiant heat. In the course of these inquiries, he has shown that the different aëriform bodies, even though colourless, exert very different degrees of absorptive action on the rays of heat,—and that certain portions of these heat-rays are more powerfully absorbed than others—rays from objects at a low temperature being more easily absorbed than those from objects at an elevated temperature. He has also proved that gases radiate as well as absorb, and, in conformity with what is known in the case of solids, that in gaseous media also there is equality in the powers of radiation and absorption. Bodies which exert an absorbent effect in the liquid form preserve it in the gaseous state. If further experiments should confirm Prof. Tyndall's views upon the absorptive action of aqueous vapour upon radiant heat of low intensity, these results must materially modify some of the views hitherto held upon the meteorological relations of aqueous vapour.

The Bakerian lecture, by Mr. Sorby, is entitled by him "On the Direct Correlation of Mechanical and Chemical Forces." In this paper are embodied a series of observations upon the influence of pressure upon the solubility of salts, in which he has obtained results analogous to the changes observed in the freezing-point of liquids under pressure. He finds, in cases where, as is usual, the volume of the water and the salt is less than the volume of the water and the salt separately, that the solubility is increased by pressure, but that, in cases where (as when sal-ammoniac is dissolved in water) the bulk of the solution is greater than that of the water and salt taken separately, the solubility is lessened by a small but measurable amount. On the contrary, salts which expand in crystallizing from solution must, under pressure, overcome mechanical resistance in that change; and as this resistance is opposed to the force of crystallization, the salt is rendered more soluble. The extent of the influence of pressure, and the mechanical value of the force of crystalline polarity, were found to vary in different salts. Mr. Sorby also indicates the results of the action of salts upon certain carbonates under pressure, and purposes pursuing his researches upon chemical action under pressure. This paper may, therefore, be regarded as the first of a series upon a highly interesting and important branch of investigation, for which Mr. Sorby appears to be specially fitted, from his combining the needful geological knowledge with the skill in manipulation required in the physical and chemical part of the enquiry.

The examination of the bright lines in the spectra of electric discharges passing through various gases, and between electrodes of various metals, has of late years attracted very general attention. Each elementary gas and each metal shows certain well marked characteristic lines, from the presence or absence of which it is commonly assumed that the presence or absence of the element in question may be inferred. But the question may fairly be asked, has it been established that these lines depend so absolutely on chemical character that none of them can be common to two or more different bodies? Has it been ascertained that, while the chemical nature of the bodies remains unchanged, the lines never vary if the circumstances of mass, density, &c., are changed? What evidence have we that spectra are superposed, so that we observe the full sum of the spectra which the electrodes and the medium would produce separately?

To examine these and similar questions in the only unimpeachable way (that of actual experiment) formed the object of a long and laborious research by Dr. Robinson, the results of which are contained in a paper in our Transactions. In the course of this research, Dr. Robinson had occasion to take careful measures of the positions of all the bright lines visible (and not too weak to measure) in a great number of spectra—those, namely, of the induction discharge passing between electrodes of twenty different metals, as well as graphite, most of which were observed in each of five different gases (including air), and for each gas separately at the atmospheric pressure and at the low pressure obtained by a good air-pump.

On taking an impartial survey of this great assemblage of experimental facts, Dr. Robinson inclines to the opinion that the origin of the lines is to be referred to some yet undiscovered relation between *matter in general* and the transfer of electric action; and that while the *places* of the lines are thus determined independently of particular circumstances, the *brightness* of the lines is modified, according to the special properties of the molecules which are present, through a range from great intensity down to a faintness which may elude our most powerful means of observation.

By a discussion of the results of the magnetic observations maintained for several years past at the Kew Observatory with an accuracy previously unattained, and by combining these with the earlier results of the observations at the British colonial observatories, I have been enabled to trace, and, as I believe, satisfactorily to establish the existence of an annual variation in the three elements of the earth's magnetism, which has every appearance of being dependent upon the earth's position in its orbit relatively to the sun. Substantiated by the concurrent testimony of observation in both hemispheres, and in parts of the globe most widely distant from each other, this conclusion furnishes an additional evidence of a cosmical magnetic relation subsisting between the earth and other bodies of the solar system, and thus extends the scope and widens the basis of sound induction upon which the permanent relations of magnetical science must rest.

To Dr. Otto Torell, Professor of Zoology in the University of Lund, we are indebted for a communication of much interest, informing us of the progress made by an expedition appointed by the Swedish Government at the recommendation of the Royal Academy of Sciences at Stockholm, to execute a survey preliminary to the measurement of an arc of the meridian at Spitzbergen. The objects of the preliminary survey were to ascertain whether suitable angular points for a triangulation could be found from Ross Island at the extreme north, to Hope Island at the extreme south of Spitzbergen, and to determine on a favourable locality for the measurement of a base-line. The result of the first year's exploration has been the selection of stations, on hills of moderate height and easy access from the coast, for nine triangles shown in the sketch accompanying Dr. Torell's paper, including Ross Island in the extreme north, and extending over about 1° 50′ of the proposed arc of 4½ degrees. A convenient locality has also been found for the base-line. The continuation of the preliminary survey to the extreme southern limit is to be the work of the summer of 1864. The report of the Geodesical Surveyors has shown that the northern portion presents no impediments which may not be surmounted by courage and perseverance; and with regard to the southern portion, the knowledge already acquired is considered to justify the expectation that the result of the second year's exploration will be no less favourable. Should such be the case, it is anticipated that the necessary steps will be taken for carrying into execution the measurement of the arc itself.

I may perhaps be permitted to allude for a moment to the peculiar interest with which I must naturally regard the proposed undertaking. The measurement of an arc of the meridian at Spitzbergen is an enterprise which nearly forty years ago was a cherished project of my own, which I had planned the means of executing, and which I ardently desired to be permitted to carry out personally. I may well therefore feel a peculiar pleasure in now seeing it renewed under what I regard as yet more promising auspices,—whilst I cannot but be sensible of how little I could have anticipated that I should have had the opportunity, at this distance of time, and from this honourable chair, of congratulating the Swedish Government and Academy upon their undertaking, and of thanking Dr. Torell for having traced its origination to my early proposition.

It is well remarked by Dr. Torell, that the triangulation, should it be proceeded with, will not be the only result of the years of scientific labour at Spitzbergen. There are, indeed, many important investigations for which the geographical circumstances would be eminently favourable. Two such may be specified, for which we may reasonably anticipate that full opportunity would be afforded, and for which the requisite instruments of precision are neither costly nor cumbersome. One is a more exact determination of the data on which our Tables of Astronomical Refraction are founded. The other is the employment of Cagnoli's method for determining the figure of the earth by occultations of the fixed stars.* This last would be tried under circumstances far more favourable than those contemplated by its original proposer, by reason of the high latitude of the northern observer—the greater number of stars in the moon's path, now included in our catalogues, of which a special ephemeris might be made—and the much greater amount of concerted corresponding observations which might now be secured. The advantage peculiar to this mode of determination is, that it is exempt from the influence of local irregularities in the direction and force of gravity which embarrass the results of the measurements of degrees and of pendulum experiments. As a third and thoroughly distinct method of investigation, it seems at least well deserving of a trial.

Swedish naturalists are not likely to undervalue the interest attaching to careful examinations of the constancy or variation of the elevation of land above the sea-level; and I may therefore venture to refer them to a paper in the Phil. Trans. for 1824 (Art. xvi.) written from Spitzbergen itself in July, 1823, containing the particulars of a barometrical and trigonometrical determination of the height (approximately 1644 English feet) of the well-defined summit of a conspicuous hill in the vicinity of Fairhaven. The barometrical comparison was repeated on several days, the barometer on the summit of the hill being stationary, and the observation of the two barometers strictly simultaneous, the stations being visible from each other by a telescope. The height as given by the two methods, barometrical and trigonometrical, was in excellent accord. The hill may be identified with certainty by the plan which accompanies the paper referred to: it is easy of access, and may be remeasured with little difficulty.

It will be remembered that a few years ago the attention of the Royal Society was called by the Foreign Office to the circumstance of several glass bottles with closed necks having been found on the shores of the west coast of Nova Zembla, leading to a conjecture that they might afford some clue to the discovery of the missing ships of Sir John Franklin's expedition. The inquiries instituted by the Royal Society traced the bottles in question to a recent manufacture in Norway, where they are used as floats to the fishing-nets employed on that coast. These floats, accidentally separated from the nets, had been carried by the stream-current which sets along the Norwegian coast round the North Cape, and thus afforded evidence of the prolongation of the current to Nova Zembla. The Swedish Expedition, in the course of its summer exploration, found on the northern shore of Spitzbergen several more of these bottle-floats, some of which even bore Norwegian marks and names, supplying evidence, of considerable geographical interest, of the extension of the Norwegian stream-current to Spitzbergen, either by a circuitous course past the shores of Nova Zembla, or by a more direct offshoot of which no previous knowledge existed. It is thus that step by step we improve our knowledge of the currents which convey the waters of the more temperate regions to the Polar seas and produce effects which are traceable in many departments of physical geography.

The application of gun-cotton to warlike purposes and engineering operations, and the recent improvements in its manufacture, have been the subject of a report prepared by a joint Committee of the Chemical and Mechanical Sections of the British Association, consisting chiefly of Fellows of the Royal Society. The report was presented at the meeting in Newcastle in September last, and is now in the press. The Committee had the advantage of personal communication with General von Lenk, of the Imperial Austrian Artillery, the inventor of the system of preparation and adaptation by which gun-cotton has been made practicably available for warlike purposes in the Austrian service. On the invitation of the Committee, and with the very liberal permission of the Emperor of Austria, General von Lenk visited England for the purpose of thoroughly explaining his system; and we have in the Report of the Committee, the information, thus gained directly from the fountain-head, of the results of his experience in the course of trials extending over many years, together with additional investigations by individual members of the Committee.

The advantages which are claimed for gun-cotton over gunpowder for ordnance purposes and mining operations are so many and so important as to call imperatively for the fullest investigation. Such an inquiry, however, in its complete sense, is both beyond and beside the scope and purposes of a purely scientific body; and the British Association have done well (whilst re-appointing the Committee to complete certain experiments which they had devised with the view of clearing up some scientific points which are still more or less obscure) in pressing on the attention of her Majesty's Government the expediency of instituting under its own auspices a full and searching inquiry into the possible applications of gun-cotton in the public service.

The absence of smoke, and the entire freedom from the fouling of the gun, are points of great moment in promoting the rapidity of fire and the accuracy of aim of guns employed in casemates or in the between decks of ships of war; to these we must add the innocuous character of the products of combustion in comparison with those of gunpowder, and the far inferior heat imparted to the gun itself by repeated and rapid discharges. With equal projectile effects, the weight of the charge of gun-cotton is but one-third of that of gunpowder; the recoil is stated to be reduced in the proportion of 2 to 3, and the length of the gun itself to admit of a diminution of nearly one-third. These conclusions are based on the evidence of long and apparently very carefully conducted courses of experiment in the Imperial Factory in the neighbourhood of Vienna. The results appear to be especially deserving the attention of those who are engaged in the important problems of facilitating the employment of guns of large calibre and of great projectile force in the broadsides of our line-of-battle ships, and in reducing, as far as may be possible, the dimensions of the ports.

In the varied applications of explosive force in military or civil engineering, the details of many experiments which bear on this branch of the inquiry are stated in the Report of the Committee, and appear to be highly worthy of consideration and of further experiment.

It cannot be said that the advantages now claimed for gun-cotton are altogether a novel subject of discussion in this country. When the material was first introduced by Schonbein in 1846, its distinctive qualities in comparison with gunpowder were recognised, although at that period they were far less well ascertained by experiment than they are at present. To the employment of gun-cotton as then known there was, however, a fatal drawback in its liability to spontaneous combustion. The elaborate experiments of General von Lenk have shown that this liability was due to imperfection in its preparation, and ceases altogether when suitable processes are adopted in its manufacture. Perfect gun-cotton is a definite chemical compound; and certain processes for the removal of all extraneous matter and of every trace of free acid are absolutely indispensable. But when thus prepared it appears to be no longer liable to spontaneous combustion, it can be transported from place to place with perfect security, or be stored for any length of time without danger of deterioration. It is not impaired by damp—and may be submerged without injury, its original qualities returning unchanged on its being dried in the open air and at ordinary temperatures.

A scarcely less important point towards the utilisation of gun-cotton and the safety with which it may be employed in gunnery is the power of modifying and regulating its explosive energy at pleasure, by means of variations in the mechanical structure of the cartridge, and in the relative size of the chamber in which it is fired.

The experiments made by the Austrian Artillery Commission, as well as those for blasting and mining, were conducted on a very large scale; with small arms the trials appear to have been comparatively few.

* Antonio Cagnoli, "Nuovo e sicuro mezzo per riconoscere la Figura della Terra," Memorie della Società Italiana, Verona, vol. vi. 1792.
An English translation, with Notes and an Appendix, was printed for private circulation in 1819, by Mr. Francis Baily.

There can be no hesitation in assenting to and accepting the concluding sentence of the Committee's report. "The subject has neither chemically nor mechanically received that thorough investigation that it deserves. There remain many exact measnres still to be made, and mauy important data to be obtained. The phenomena attending the explosion of both gun-cotton aud gunpowder have to be investigated, both as to the temperatures generated in the act of explosion and the nature of the compounds which result from them, under circumstances strictly analogons to those which occur in artillery practice."

The Copley Medal has been awarded to the Reverend Adam Sedgwick, for his observations and discoveries in the Geology of the Palæozoic Series of Rocks, and more especially for his determination of the characters of the Devonian System, by observations of the order and snperposition of the Killas Rocks and their fossils, in Devonshire.

Mr. Sedgwick was appointed Woodwardian Professor of Geology in the University of Cambridge in the year 1818, since which time, up to a recent period, comprising an interval of upwards of forty years, he has devoted himself to geological researches with an ability, a persistent zeal, and untiring perseverance which place him amongst the foremost of those eminent men by whose genius, sagacity, and labours the science of geology has attained its present high position. To duly appreciate his earlier work as a geological observer and reasoner, we must recall to recollection the comparative ignorance which prevailed forty or fifty years ago, to the dispersion of which his labours have so largely contributed. Geology was then beset by wild and untenable speculations on the one hand, whilst on the other even its most calm and rational theories were received by many with distrust or with ridicule—and by others with aversion, as likely to interfere with those convictions on which the best hopes of man repose.

Under such circumstances geology needed the support and open advocacy of men who, by their intellect aud acquirements, and by the respect attached to their individual characters, their profession, or social position, might be able ou the one hand to repress wild fancies, and on the other to rebut the unfounded assertions of those who opposed the discussion of scientific truth. Such a man was Professor Sedgwick, and such was the influence he exerted. It may be well to make this allusion ou an occasion like the present, because it often happens, not unnaturally, that those who are most occupied with the questions of the day, in an advancing science, retain but an imperfect recollection of the obligations due to those who laid the first foundation of our subsequent knowledge.

More than forty years have passed since Professor Sedgwick began those researches among the older rocks of England which it became the main purpose of his life to complete. In 1822 was begun that full and accurate survey of the magnesian limestone of the North of England which to this day holds its high place iu the estimation of geologists as the foundation of our knowledge of this important class of deposits, whether we regard their origin, form of deposition, peculiarities of structure, or organic contents.

Contemporaneously with this excellent work, he examined the Whin Sill of Upper Teesdale, showed its claims to be treated as a rock of fusion, and discussed the perplexed question of its origin.

Advancing to one of the great problems which occupied his thoughts for many years, he combined in 1831 the observations of the older rocks of the Lake Mountains which he had commenced in 1822, and added a special memoir on the great dislocations by which they are sharply defined and separated from the Penuine chain of Yorkshire. Memoirs followed in quick succession on the new red sandstone of the Vale of Eden; on the stratified and unstratified rocks of the Cumbrian Mountains, and on the limestone and granite veins near Shap. Thus, thirty years since, before the names of Cambrian and Silurian were ever heard, under which we now thankfully class the strata of the English lakes, those rocks had been vigourously assailed and brought into a lucid order and system which is to this day unchanged, though by the same hands which laid the foundations many important additions have been made, one of signal value in 1851—the lower palæozoic rocks at the base of the carboniferous chain between Ravenstonedale and Ribblesdale. Perhaps no district iu the world affords an example of one man's researches begun so early, continued so long, and ending so successfully. By these persevering efforts, the geology of the lake district came out into the light; and there is no doubt, and can be no hesitation in ascribing to them the undivided honour of the first unrolling of the long series of deposits which constitute the oldest groups of British Fossiliferous Rocks.

Still more complete, however, was the success of that work which was undertaken immediately afterwards on the coeval rocks of Wales; by which Professor Sedgwick and Sir Roderick Murchison, toiling in separate districts, unravelled the intricate relations of those aucient rocks, and determined the main features of the successive groups of ancient life which they enclose. These labours began in 1831-32, and in 1835 the two great explorers had advanced so far in their search as to present a united memoir to the British Association in Dublin, showing the progress each had made in the establishment of the Cambrian and Silurian systems, as they were then called; Professor Sedgwick taking the former, and Sir Roderick Murchison the latter for his special field of study.

In 1843 Professor Sedgwick produced two memoirs on the structure of what he then termed the Protozoic rocks of North Wales. Many excellent sections were given in detail in these memoirs; those exhibiting the structure of the western part of the district about Carnarvonshire being principally taken from his observations in 1831-32, while the more detailed sections of the eastern part were from those of 1842-43. These two papers gave the complete outline or framework, as it were, of the geological structure of this intricate region. In several subsequent years he continued to fill up this outline with further details, observed almost entirely by himself, giving numerous general and local sections, by which he determined the dip and strike of the beds, normal and abnormal, and all the great anticlinal and synclinal lines on which the fundamental framework depends.

Further and still minuter details were subsequently given. as was to be expected by the Government Surveyors; but the general arrangement finally recognized on the map of the survey, is essentially the same as that previously worked out by his unaided labours.

It was a principle always advocated by Professor Sedgwick, that the geological structure of a complicated district could never be accurately determined by fossils alone without a detailed examination of its stratification. He always proceeded on this principle; nor (from the paucity of organic remains) would it have been possible on any other principle to have determined the real geological character of those older districts which he investigated so successfully. His arrangement and nomenclature of the Cambrian rocks in North Wales (the Lower Silurians of Sir Roderick Murchison) are given in his "Synopsis of the Classification of the British Palæozoic Rocks," 1855. It possesses the weight which must always be recognized as appertaining to the authority of the geologist who, by his own labours, first solved the great problem of the physical structure of the district.

There are other important memoirs of Professor Sedgwick's of which time forbids more than a very passing notice. The memoir "On the Structure of Large Mineral Masses," published in 1831, was the first, and remains to this day, the best descriptive paper which has yet appeared ou joints, planes of cleavage, nodular concretions, &c.

Always attentive to the purpose of preparing a complete and general classification of the Palæozoic Strata, Professor Sedgwick, at an early period in his career, printed a memoir "On the Physical Structure of the Older Strata of Devon and Cornwall;" and another "On the Physical Structure of the Serpentine District of the Lizard." Of later date are several papers written by him conjointly with Sir Roderick Murchison, respecting the Devonian system. The principal of these, published in 1840, comprised the work of several previous years, and made known the true nature of the *Culm Beds* of North Devon, as belonging to the carboniferous series, and their position in a trough of the subjacent rocks, which rocks, on account of their position and their organic contents, were concluded to belong to the Devonian, or Old Red Sandstone period, a conclusion which was at first controverted, but was ultimately admitted. In another memoir by the same authors in 1828, they conclude that the coarse old red conglomerate along the north-western coast of Scotland and in Caithness is of about the same age as the Old Red Sandstone of South Wales and Herefordshire, and therefore of the Devonian period. They also published in 1840 an account of their general observations on the Palæozoic Formations of Belgium and the banks of the Rhine, the results of which were considered to harmonise with those derived from other localities. Finally, we may notice another joint memoir by these authors in 1830, "On the Structure of the Eastern Alps," which, however, had no immediate relation to the researches on the Palæozoic formations.

It will be observed that the memoirs which have been noticed are for the most part pervaded by a certain unity of purpose. The investigations were not on points of merely local interest, but were essential for the elucidation of the geological history of our planet during those early periods of which the records are most difficult to unfold. Few persons, perhaps, can have an adequate idea of the difficulties he had to contend with when he first entered North Wales as a geologist. Geologically speaking, it was a *terra incognita* of which he undertook to read the geological history before any one had deciphered the characters in which it is written. Moreover, besides the indistinctness and complexity of the stratification, and the obscurity which then prevailed as to the distinction between planes of stratification and planes of cleavage, there was also the difficulty of what may be called "mountain geometry"—that geometry by which we unite in imagination lines and surfaces observed in one part of a complicated mountain or district with those in another, so as to form a distinct geometrical conception of the arrangement of the intervening masses. This is not an ordinary power; but Mr. Sedgwick's early mathematical education was favourable to the cultivation of it. We think it extremely doubtful whether any other British geologist forty years ago could have undertaken, with a fair chance of success, the great and difficult work which he accomplished.

Such are the direct and legitimate claims of Professor Sedgwick to the honour conferred upon him by the award of the Copley Medal. But there are also other claims, less direct, but which it would be wrong to pass altogether unnoticed. It is not only by written documents that knowledge and a taste for its acquirement are disseminated; and those who have the good fortune to attend Professor Sedgwick's lectures, or may have enjoyed social intercourse with him, will testify to the charm and interest he frequently gives to geology by the happy mixture of playful elucidation of the subject with the graver aud eloquent exposition of its higher principles aud objects.

The Council has awarded a royal medal to the Rev. Miles Joseph Berkeley for his researches in Cryptogamic Botany, especially in Mycology.

The Council has awarded a royal medal to John Peter Gassiot, Esq., for his researches on the Voltaic Battery and Current, and on the Discharge of Electricity through Attenuated Media.

These contributions, most of which are recorded in our "Transactions," are of high value, and in some respects peculiar. Their experimental part has been conducted on a scale of magnitude and power unmatched since the days of Davy and of Children, with apparatus of the highest perfection, aud with consummate dexterity aud skill; and the discussion and interpretation of the facts observed are characterised by sound theory and sober judgment.

It would trespass too much on your time were I to give a detailed account of them, and I shall only select a few which are examples of what Bacon has called "Instantiæ Crucis," such as, when the mind is undecided between several paths, point out the true one.

1. The first decides a question which was long debated with great vehemence, whether the energy of the Voltaic Battery arises from the contact of its metals, or from chemical action. The first of these opinions was mainly supported by the fact that, when two dissimilar metals are made to touch, they show signs of opposite electricities when separated. Mr. Gassiot showed, in 1844, that the

same occurs when the metals are separated by a thin stratum of air without having been in previous contact.

2. The identity of voltaic with frictional electricity was denied by many, because it gave no spark through an interval of air. Davy had indeed asserted the contrary in his "Elements of Chemical Philosophy," but his statement seems to have been doubted or unheeded. Mr. Gassiot, in the "Transactions" for 1844, has put the fact beyond dispute; he showed that by increasing the number of cells and carefully insulating them, sparks can be obtained even with the feeblest elements. With 3520 cells, zinc and copper excited with rain water, he obtained sparks in rapid succession through $\frac{1}{50}$ of an inch of air; and a little later added to this a fact of still higher significance, that by exalting the chemical action in the cells, the same or even greater effect could be produced by a much smaller series. The battery of 500 Grove's cells which was constructed for these experiments is probably in some respects the most powerful that was ever made.

3. The currents produced by electric or magnetic induction are of the highest interest, and the employment of them as a source of electric power is almost daily enriching physical science with precious results. In this new field Mr. Gassiot has been one of the most successful explorers. So early as 1839 he showed that the induction current gives a real spark, and he found that in the flame of a spirit-lamp it could strike at a distance of $\frac{3}{4}$ths of an inch.

4. The splendid phenomena produced by the discharge of the induction current through rarefied gases or vapours are well known; in particular the stratification of the light. The cause of this is not yet fully understood, but Mr. Gassiot has made some very important additions to our knowledge of it in the Bakerian Lecture for 1858, and his subsequent communications to the Society. Among these may be named his explanation of the occasionally reversed curvature of the strata, and his discovery of the Reciprocating discharge, which, seeming single, is composed of two, opposite in direction, but detected by the different action of a magnet on each of them—a beautiful test, which is of wide application in such researches. Again, the Torricellian vacuum which he used at first, even when absolutely free from air, contains mercurial vapour: by applying to his tubes a potent freezing mixture, he found that as this vapour condensed, the strata vanished, the light and transmission of electricity decreased, till at a very low temperature both ceased entirely. It follows from this that a perfect vacuum does not conduct—a fact of cosmical importance, which had been surmised before, but not proved; and the desire of verifying this discovery led him to a means of far higher rarefaction. A tube containing a piece of fused hydrate of potassa is filled with dry carbonic acid, exhausted to the limit of the air-pump's power, and sealed; then by heating the potassa, the residual carbonic acid is mostly, or even totally absorbed. Vessels so exhausted, though still containing vapour of potassa, and perhaps of water, have a better vacuum than had been previously obtained, and often cease to conduct till a little of the alkali is vaporised by heating them, and the gradual progress of the exhaustion gives a wide range of observation.

5. The current of an induction machine is necessarily intermittent, and it has been supposed that the strata are in some way caused by the intermittence, and are possibly connected with the mode of action of the contact-breaker. Mr. Gassiot has, however, shown that they are perfectly developed in the discharge of an extended voltaic battery through exhausted tubes. The large water-battery already mentioned shows them in great beauty; the discharge, however, is still intermittent.

6. The same appearance is exhibited by a Grove's battery of 400 well-insulated cells; but in this case a new and remarkable phenomenon presents itself. At first the discharge resembles that obtained from the water-battery, and is like it intermittent; but *suddenly* it changes its character from intermittent to continuous (so far at least as can be decided by a revolving mirror), and everything indicates that we have now the true voltaic arc. The discharge is now of dazzling brilliancy, *and is stratified as before*, whence it appears that strata are capable of being produced by the true arc discharge.

7. This change is accompanied by a remarkable alteration in the heating of the two electrodes. Mr. Gassiot had previously shown that, in the ordinary voltaic arc, formed in air of the usual pressure, the *positive* electrode is that which is the more heated, whilst in the discharge of an induction machine, whether sent through air at the ordinary pressure between electrodes of thin wire, or through an exhausted tube, it is the *negative*. The discharge through the large Grove's battery, so long as it was intermittent, agreed with the induction discharge in this character as in others, that the *negative* electrode was that which became heated; but when the discharge suddenly and spontaneously passed from the intermittent to continuous, the previously heated negative electrode became cool, and the positive was intensely heated.

These brief references will suffice to show what a high place Mr. Gassiot holds amongst those who are investigating this new track, which promises such great advance in our knowledge of those molecular forces in the study of which all physical science must ultimately centre. I may be permitted to add, that in his whole career he has sought not his own fame, but the advancement of science: he has rejoiced as much in the discoveries of others as in his own, and aided them by every appliance in his power. I cannot refrain from mentioning a recent instance in which this liberal and unselfish spirit has been strikingly exhibited. He has had executed a grand spectroscope, furnished with no less than nine faultless prisms, a design in which he has been ably seconded by the skill of the optician, Mr. Browning, to whom the construction was entrusted. This magnificent instrument he has placed at the disposal of any Fellow of the Society who may happen to be engaged in researches requiring the use of such powerful apparatus. The instrument is at present at the Kew Observatory, where it is in contemplation to undertake the construction of a highly elaborate map of the spectrum.

Mr. Gassiot is still pursuing his electrical researches, and we may be assured that he will feel this acknowledgment of his labours by the Royal Society, not merely as a recompense for that he has accomplished, but as an obligation to continued exertion and new discoveries.

On the motion of Professor Owen, seconded by Mr. Gwyn Jeffreys, it was resolved—"That the thanks of the Society be returned to the President for his Address, and that he be requested to allow it to be printed."

INSTITUTION OF CIVIL ENGINEERS.

JOHN HAWKSHAW, ESQ., PRESIDENT, IN THE CHAIR.

In the interval that had elapsed since the last annual general meeting, it was gratifying to the council to be able to state, that the progress of the Institution had been eminently satisfactory. The "papers" read at the meetings had been numerous and varied; the meetings themselves had been very fully attended; the library had received considerable accessions, both by donations and by purchases; the number of members had steadily increased, and the funds were in a prosperous condition. These were certain tests that the Institution continued to be appreciated by those in whose interest it was established, and led to the conclusion that, so long as its affairs were conducted as they hitherto had been, similar support and countenance would be extended to it.

An enumeration of the papers read and discussed at the ordinary general meetings showed the variety of subjects which engaged the attention of engineers at the present day, and the extended area embraced within the operations of the members of the profession. Many of the papers read during the last two sessions had, at the request of the authors, been issued already in a separate form, so that the volumes xxi. and xxii. of the Minutes of Proceedings for the Sessions 1861–2 and 1862–3 might be said to be completed, and would be issued in the course of a few weeks. An index of the series from vol. i. to vol. xx. inclusive was in hand, and though a task involving considerable labour, had already advanced fully one half. Numerous applications having been received from the members for complete sets of the Minutes of Proceedings, the council had determined to reprint some of the earlier numbers which were out of print, in order to be enabled to supply this evident want.

The tabular statement of the transfers, elections, deceases, and resignations, showed that the number of elections had been 74, of deceases 26, of resignations 5, and of erasures 3, leaving an effective increase of 40, and making the total number of members of all classes on the books on the 30th of November last, 1,040. This was an increase of nearly 39 per cent. in the last ten years, of which 4 per cent. occurred in the past session. During the last ten years the number of members had increased to a greater extent than the associates; for, whereas the numbers of those classes on the 30th of November, 1853, were 259 and 441 respectively, or in the proportion of 1 to 1·7, on the 30th November last these numbers were 425 and 588, or as 1 to 1·4.

The deceases during the past year had been:—John Singleton Copley, Lord Lyndhurst, and William Tooke, Honorary Members; Thomas Evans Blackwell, William Clegram, Richard Carden Despard, James Fenton, Joshua Field, Joseph Glynn, Mark Jones, William Lewin, and Captain William Scarth Moorsom, Members; Beriah Botfield, M.P., Alexander Bremner, Alexander Brodie Cochrane, William Coulthard, William Cubitt, M.P., William Dunlop, Charles Michael Joplin, Francis Morton, Geddie Pearse, Apsley Pellatt, William Rigby, Charles William Scott, James Sherriffs, Admiral Washington, and William Richard Whitmore, Associates.

It would be observed with deep regret that while the Institution had lost many useful and able members, there was included in the list one whose memory must ever be regarded with the liveliest interest; for to Mr. Joshua Field, to whom allusion was made, was due, in no small degree, the existence of the Institution of Civil Engineers. It was about the year 1816, that Mr. Henry Robinson Palmer, who was then articled to Mr. Bryon Donkin, first suggested to Mr. Field the idea of forming a society of young engineers, for their mutual improvement in mechanical and engineering science; and it was no doubt owing to Mr. Field's influence that Mr. William Nicholson Maudslay became the third who associated in this cause. These were shortly joined by five others—Mr. James Jones, Mr. Charles Collinge, Mr. James Ashwell, Mr. Thomas Maudslay, and Mr. John T. Lethbridge—and when the Institution was constituted on the 2nd of January, 1818, it comprised just these eight members, and so remained until the following year, when the number was increased by three. From that time to the present the numbers had steadily increased, the first great impetus being the acceptance of the office of president, in 1820, by Telford, under whose fostering hand the Institution grew rapidly in importance, and eventually acquired a permanent position among the scientific societies of the metropolis.

The abstract of receipts and expenditure, as prepared by the auditors, showed that the income from all sources, during the twelve months from the 1st December, 1862, to the 30th November, 1863, was £3974 17*s.* 1*d.*, while the payments in the same period only amounted to £2740 8*s.* 11*d.*, leaving a balance of £1231 8*s.* 2*d.* Of this, a sum of £1000 had been invested in the purchase of London and North-Western Railway Four per cent. Debenture Stock, making a total of investments during the last five years, out of the general funds, of £3500. The realised property of the Institution now comprised:—1. General Funds, £9357 0*s.* 8*d.*; 2. Building Fund, £1322 2*s.* 11*d.*; and 3. Trust Fund, £9970 12*s.* 7*d.*, making a total of £20,649 16*s.* 2*d.*, as against £19,041 12*s.* 1*d.*, at the same period last year.

The Institution was now about to enter upon the forty-seventh year of its existence. It remained for the present members to emulate the example of those who had preceded them, and to sustain the high character for usefulness which the Institution had always enjoyed.

After the reading of the report, Telford medals and Telford premiums o books were presented to Messrs. J. Brunton, J. R. Mosse, Z. Colburn, and H Hayter; Telford premiums of books to Messrs. W. M. Peniston, W. H. Preece A. W. Makinson, D. Miller, R. Crawford, W. Cudworth, and J. G. Fraser; and a Watt medal and the Manby premium, in books, to Mr. J. Fernie.

ROYAL GEOGRAPHICAL SOCIETY.

Lord Strangford in the Chair.

NOTES ON THE ISLAND OF FORMOSA.

By Robert Swinhoe, F.G.S., &c., H.M.'s Vice-Consul on the Island.

The island of Formosa is a *foo* or district of the Chinese province of Fokien, and is governed by a special Taou-Tai, who may memorialise the throne direct. Mr. Swinhoe doubts whether, owing to its bad anchorage and bad harbourage, Tai-Wan-Foo can ever become a centre of British trade, especially as there are known to be other and far more suitable ports. After marching overland to Tai-Wan-Foo, which is described as girt by a high battlemented wall, six miles in extent, the paper mentioned that the town was fast going to decay owing to the silting up of the river. The difficulty of navigating the coast of Formosa is great, and there are numerous wrecks of vessels that are compelled to run for a port, and are iguorant of several excellent harbours unsurveyed near the south end of the island. On the north-west coast is the Tam-suy River, which Mr. Swinhoe seems to think destined to become the British port of trade, there being 16ft. of water at high tide over the bar. The capital, Foo Chow, is not far distant, and there are several natural landmarks for facilitating navigation. The chief danger is from the freshets in the early summer, when the mountain-snows melt. The river, in its upper course, is formed by two chief branches, near one of which are sulphur mines. Among other improvements effected by native skill is their having, about 40 years since, diverted a large stream of water so as to make amends for the very bad water on the plains. There is a wooden aqueduct, 5ft. deep, 8ft. broad, and about 360ft. in length, which has been rendered water-tight with Chinese cement. Not far distant from this the territory of the aboriginal savages inhabiting the east coast is reached, where the division line is strongly marked by the Chinese side being denuded of trees, for the cultivation of the tea-plant, while the native side is covered with the usual forest vegetation. Great quantities of rain fall from November to May, making the climate comparatively cold, as is evidenced by a table drawn up with considerable care. This excess of moisture the author attributes to an oceanic stream known as the Kurosino, which departs at the south cape of Formosa. and extends along its east side and past the eastern shore of Japan even to the Kurile islands, and is supposed to run for some distance alongside of a much warmer stream coming up from the Philippines. From the bold appearance of the eastern, northern, and north-western coast, the coast-line is assumed to be receding if anything. Excellent lignite coal is procured at Coal Harbour, on the north-east corner. There is fair sound tea on the island, besides rice, sugar, jute, grass-cloth fibre, rice paper, rattans, barley, wheat (superior to that of the mainland) camphor, petroleum, and dyewoods, and a constantly-increasing import, chiefly opium.

LONDON ASSOCIATION OF FOREMEN ENGINEERS.

Mr. J. Newton in the Chair.

At the last meeting, on the 5th ult., the chairman directed, in a few feeling remarks, the attention of the society to the painful circumstances which had attended the death of William Templeton, the well-known author of many mechanical and scientific works. It was needless, he said, for him to expatiate upon the claims which Templeton had upon the mechanical communities of this and other countries. His books were text-books; and his scientific memoranda, guides to all young mechanics especially. Templeton, however, had died in extreme poverty. The booksellers had reaped the fruits of his labour, and his widow inherited honour,—and destitution. As Templeton had been an honorary member of that association, Mr. Newton thought that a small sum—they could not afford a large one—should be voted from their funds for the benefit of the widow, and that in addition a voluntary subscription should be opened up in her behalf. It might not be improper to furnish some brief notes in reference to the life of William Templeton; and possibly if the scientific press—ever ready to assist in such cases—were to give them publicity, attention would be drawn to the matter of the widow's destitution beyond the walls of that room. Mr. Templeton was born at Caltrine, Ayrshire, on the 8th of February, 1796. He was the father of a large family—namely, seven sons and three daughters—of these, six of the sons were unfortunately dead. Templeton was for some time a chief engineer in the Royal Navy—in fact, for five years. He left the service, however, and, for one year subsequently, was located in the Island of Java. Failing health compelled him to leave that place, and he next went to Australia. While there, Templeton superintended the erection of a breakwater at Port Elliot, and wrote a small work, known under the title of the "Commercial Prompter." On returning from Australia, he devoted himself to scientific literature. His principal works are the "Millwright and Engineer's Pocket Companion," "The Steam Engine Popularly Explained," "Mathematical Tables," "The Workshop Companion," "Practical Examinator," "The Engineer's, Millwright's, and Machinist's Practical Assistant," and others of a like character. The poor author died in London on the 12th of August last, aged and destitute.—At the conclusion of these remarks, Mr. Blackett explained the circumstances attending the last hours of Mr. Templeton, and confirmed the chairman's statement as to the sad condition of his widow.—On the motion of Mr. Ross, it was agreed to devote the sum of £5 from the funds of the association for the relief of that lady, and, at the same time to open a subscription list in her behalf.—Finally, a committee was nominated to receive contributions to that end. The committee comprise:—Mr. William Ross, Messrs. Rennie's, Holland-street, Blackfriars; Mr. John Ives, Messrs. Henry Grissell and Co.'s, Regent's Canal Ironworks; and Mr. Sanson, of 20, Cannon-street, City, either of which gentlemen will be happy to receive any sums, large or small, in trust for the widow Templeton.—We trust that throughout the country there will be a generous response to the appeals of the committee of the Association of Foremen Engineers of London.

SCOTTISH SHIPBUILDERS' ASSOCIATION.

ON IRON: ITS MOLECULAR STRUCTURE AND ITS MAGNETIC DISTRIBUTION.

By Mr. Paul Cameron.

The subject I am about to call your attention to this evening is, Iron: its Molecular Structure and its Magnetic Distribution.

It is a subject attended with many difficulties which stand in the way and break the connecting links in the chain of our process of reasoning. I may frankly admit that I have not selected it with the view of clearing away these difficulties. My object is to bring before you an outline of the various theories that have been proposed, to account for the metalliferous formation, and my endeavour to trace how far the magnetical influence may have induced their structure and consolidation.

We have not as yet definite ideas of the molecular forces which induce the magnetic condition, so that on this question we are free to advance such ideas and principles as will bear the test of experiment, and from these deduce the probable results.

The great laboratory of nature presents to our view its various simple bodies. Of these there are none so important or of greater utility than the metals. They have at all times held a distinguished place. Without their assistance the mechanical arts could not have flourished, nor could mankind ever have acquired that amount of civilisation which characterises the present state of society.

The metals known to the ancients were few in comparison with the number now known to exist. They were classed as follows:—Gold, silver, copper, iron, lead, tin, mercury, antimony, bismuth, and arsenic. Seven of these were distinguished by mythological signs, of which they were viewed as symbols under the influence of the Celestial bodies, as—

Gold,	The Sun,	Sunday.
Silver,	The Moon,	Monday.
Iron,	Mars,	Tuesday.
Mercury,	Mercury,	Wedesday.
Tin,	Jupiter,	Thursday.
Copper,	Venus,	Friday.
Lead,	Saturn,	Saturday.

The metals are seldom found in a pure state, and are generally formed at considerable depth under the surface of the earth, in deposits called metallic veins. Gold, silver, and mercury are occasionally found in nearly a pure state, and are called native. Metallic veins are generally found in what are called the primitive rocks, such as granite and slate; and they run generally in an easterly and westerly direction. Iron is seldom found in a pure metallic state; it is generally found in chemical combination. In this state it is called an ore, the metal of which is separated by the smelting process—that is, the melting out of the metal from its earthy combinations, which is effected by such foreign substances as will, by their chemical affinities, assist in the separation of the metal. The different methods of roasting and smelting of the iron I may pass over, and come to the primary question—How were the metals consolidated?

For the origin of the metallic veins there are many theories. In the rocks that form the greater part of the earth's crust are found fractures or cracks. These fractures are often filled with minerals and matters generally differing in composition and structure from the rocks which enclose them: these fractures give strong indications of having been filled at the time of the fractured formation, and are termed by the miner "trap dykes." Again, many of those crevices or chinks are supposed to have been filled by progressive operations, and differ materially in structure from the trap: these are termed mineral veins. The question now is, How were these veins filled? The theory of old accounted for it by the agency of fire. By the geologist and practical miner many theories have been advanced, the geologist viewing the formations to be induced by igneous and aqueous causes. Dr. Collyer, in his views, forms an idea that there was a period of the earth's existence when all substances were arranged in parallel layers or strata; and when the earth's crust was formed by cooling, it was again broken up and mountains formed, and those fissures or great cracks filled with metallic matter. This theory has defects which cannot well be answered, as the intense heat would have left more distinct marks on those rocks had this been the primary formation.

A theory common among many mining engineers is, that minerals grow; that every chink or mass of ore has its root, and is crystallised in cubes. This is more particularly indicated in the ores of lead.

An extension of the aqueous theory supposes the chinks or cracks to be filled with water from above, the water holding minerals in solution, which in the course of time become crystallised within the fissures. This view of the question seems to have many interesting facts in support of it,—such as finding in the vein masses of rock and rounded boulders, also bones of animals which are supposed to have fallen in when the fractures were open, and became filled at the same time with clay.

Mr. Charles Moor, at a late meeting of the British Association, described many veins in the carboniferous limestone in different localities,

in which were numerous organic remains of different geological ages; and argues that all our mineral veins, from the oldest to the more recent, were due to the same general law. He discards both the igneous and segregation theories, and thinks that the fissures were open during different periods, and were traversed by the ancient seas, from which the minerals of the veins were deposited or crystallised by electrical and other influences.

Mr. Hopkins, a mining engineer, believes that all mineral veins have been formed by magnetic currents, and that the rocks yielded and gave them place. He further reasons, from the fact of all metals being soluble, that they may have been held in solution, and by chemical action and polar currents the chinks and fissures became filled, and swelling opened the cracks and caused new fractures, thus opening the veins by the increase of the crystals from the sides.

It has been found by experiment that minerals may be crystallised by weak currents of electricity; also the decomposing of the metals from solutions to a metallic form by the electric current. By experiment it has been found that by connecting the end of a copper wire with a metallic vein, and attaching the opposite end of the same wire with another vein, there was a current of electricity passing between them, in some cases sufficiently strong to decompose certain salts in solution. In thus reviewing the different theories, I have combined the minerals with the metals; for could we but find the key for the formation of the one, we would be enabled to open the secrets of the other.

By electricity or magnetic influence we possess the power of composing and decomposing bodies, causing the union of simple substances to form compounds; and it may be also applied to the separation of compounds into their elementary constituents. Its secret influence is actively engaged in the development of all the varied forms presented throughout nature. The forms which crystalline matters assume have been termed primary and secondary, the latter being derived from the former. The primary forms of the crystals are supposed to be six, as the cube, prism, equilateral, parallelopiped, &c. From these the varied forms of the secondary are induced.

We will now proceed to inquire what those relations are which subsist between what we shall call electric energy and innate matter. It is becoming generally admitted that electricity, magnetism, heat, and light and the molecular and cosmical forces are but modifications of the same great primary cause; and when viewed in all their varied relations, they seem converging towards one centre, from which radiate those great principles which will guide us in all our researches, electricity being one of its keys. Electricity is a power which we only know by its effects. It seems to be capable of action in all directions, moving innate matter by determined laws, which could not be sustained without a governing power to which those attributes belong. We are acquainted with the transmission of its powers through apparently imponderable bodies, as well as water, air, and gases: it induces chemical action, and presides over chemical affinities and cohesion. Its indivisable action is made known to us through its energies on material atoms, and the variableness of its motion can be conceived from the diversity of its action on these, the reconstruction of their masses thus conveying to our senses the perception of attraction, repulsion, heat, light, sound, smell, and taste, all being produced by minute vibratory movements. Before proceeding with the inquiry as to the relation subsisting between electrical energies and matter, it may be well that we assume a hypothesis, so that in our process of reasoning we may keep the following propositions clearly in view.

Energy is a function; and its immediate indications in bodies depend on the atomical structure of the mass: thus two bodies whose energies are equal, the bodies are then equal to one another.

When two bodies differ in energy, the one continues to absorb from the other until they become equal. Sensitive energy induces energy in all bodies within its sphere of action.

When a body is acted upon by energy, a progressive change takes place in the structure of that body, the change being expansion or contraction; so that these bodies may possess active energy without indicating sensitive energy—this depending on the condition of the mass. Energy in equilibrium is latent, when not in equilibrium it is sensitive. The particular molecules of matter arrange themselves in a particular way when expanding, and re-arrange when contracting; and it is the particles so changing their arrangements, if we conceive them to be of a cubic, prismatic, triangular, spheroid, or oblong form, which causes contraction at the beginning and expansion at the end. This is a law indicated by all metals. If we reason as closely as possible on the following definitions,—first, energy; second, polarity; third, expansion; and, fourth, contraction; these appear to me to form distinct principles of action. In order that we may more clearly understand these definitions, let us suppose that we take a series of small triangular steel plates, and combine them so as to form a parallelogram similar to Fig. 1, taking care that the reed or grain of the metal runs in one direction: when they are bound together, magnetise them by any convenient mode, and they will form a combined magnet, each end indicating polarity. If we now separate the triangles, each will form a distinct magnet of itself. Suppose each cube or triangle to represent certains forms of atoms which compose the mass of matter, however different the atomic forms of matter may be, these at least convey to our ideas certain atomic forms of arrangement.

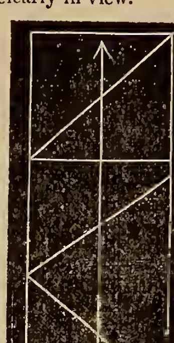


FIG. 1.

By referring to Fig. 2, it will be observed that the polarities of the cube, marked N and S, are so arranged as to attract each other, this indicating cohesive energy, also the appearance of solidity.

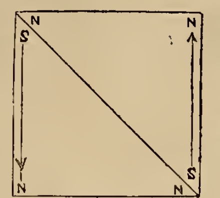


FIG. 2.

Fig 3 represents a cube and triangle attached. By this arrangement, it will be observed that the solidity is not so complete as in the former, the S, O poles repelling each other weakly, while the N, S attract each other, this arrangement weakening the solidity of the mass, and making it more brittle or sensitive to the energy of heat.

FIG. 3.

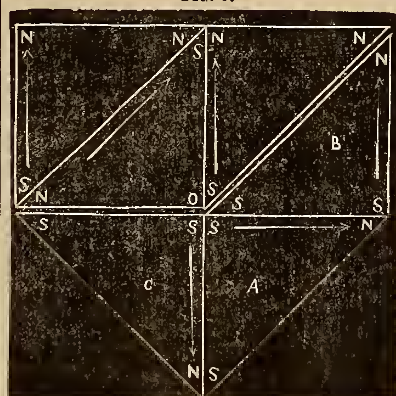


FIG. 4.

Fig. 4.—The position of the triangles forming C, A, B, then suppose the triangle A to represent an atom of hydrogen, and the triangles B and C proportions of oxygen, in this arrangement the S, S, S are repelling each other, and the N, S, attracting each other.* This arrangement, so far, represents to us the components of water, and the repulsion of the S, S, S convey an idea of the cause of fluidity; and when the energy of heat is applied, vapour or steam is the effect. The energies S, S, S convey to us an idea of the cause of the latent heat of fluids and the light vapour which arise in the absence of sensitive heat.

By reversing the triangle A, that is, to place the N to N, all the polarities would then be repellant, so that neither solid nor fluid could be formed; hence we can form an idea of the gaseous arrangements—when the energy of heat is applied, their great expansion, and when the energy of force is applied, their great compression, extreme pressure forcing many of them to assume the fluid form.

The discovery of the magnetical influence is so far back that it would only be an unnecessary waste of time to offer any history of it, as it will be sufficient to deal with that part of it which we do know. Magnetism is a science that may be still viewed as in its infancy. A few facts have been determined; and it is only within these few years that the science has assumed a few clear and distinctive fundamental principles, which observations, experiments, and time have confirmed. The term magnetism is understood to express that property which certain bodies, when charged with it, indicate—energy or motion. This condition of matter is indicated more particularly in all bodies that have iron as their basis. It is also indicated very distinctively in a mineral substance called the native magnet or loadstone. The distinctive properties of magnetism are usually expressed thus—attraction, repulsion, inducing, and receiving. These have usually been considered as constituting four distinct elements or powers. There are many good reasons to doubt the correctness of these definitions, and I think they prevent us from reasoning the science upon mechanical principles. It may be said, Why reason it upon mechanical principles? Because its indications are clearly mechanical—that of inducing and receiving. Besides, it is necessary that we reason on some known laws that we have a clear perception of; and there is no science so perfect and well understood as that of the mechanical laws—for it is only by analogy, in likening the indications of magnetism to something that we do know, that we can at all find language to express our views or ideas on the question.

The first definitions of magnetism are attraction and repulsion. These clearly imply two distinct and opposite forces. For the evidence of this we are referred to the magnetic bar, the one end attracting and the other repelling. We may naturally inquire, Does the one-half of the bar attract

* I have here referred to fluids simply to show that the same process of reasoning can be equally applied to them as metals.

the force and the other repel it? We know of no law which can assist us, by any process of reasoning, to offer an explanation. We know, by the mechanical law of forces, that forces which are equal can only remain in equilibrium, and, for the time, cease to indicate energy or force; but we know that this energy still continues. Then, does one-half of the bar receive one description of force, and the other an opposite? This seems equally absurd. Then, do the forces reside in the bar? We think not; for we know that we can induce it in bars that seemed to be free of it, so far as indicative of energy or power; we also know, when we induce magnetism by physical action or otherwise, that the structure of the mass composing the bar undergoes a change—that of expansion,—thus clearly indicating that a certain arrangement within the mass is necessary previous to its indication of the magnetical energy. We may now freely inquire, Did the mass, in its former arrangement, resist energy, or was the energy in equilibrium with the inertness of matter, waiting for the touch of energy to overcome the equilibrium of the mass and reconstruct it so as to indicate energy? Then is energy not a property of matter? We think not. Matter seems passive, and is acted upon by impulse or energy, which is co-existent with matter, but independent of it.

Let us now endeavour to explain why attraction and repulsion are indicated in the magnetic bar. I have often endeavoured to reason the magnetical indications on hydrostatical principles—that of the flow of fluids forming currents. Then let us, by analogy, suppose a current setting in any particular direction, similar to the annexed engraving. Suppose the force of the current setting from north to south. Now let us suppose the force of another current of less power, setting in the opposite direction—that is, from south to north. It will be evident that, if the opposite currents were equal, they would repel each other, and thus induce motion at right angles to that of the others; but the one being weaker than the other becomes absorbed by the stronger, so that this, so far, represents to us the effects indicated by two magnets—the poles of the weaker would be reversed by the stronger currents.

Fig. 5.

In reasoning the magnetical indications on hydrostatical principles—that is, the flow of a current—it may be necessary, before proceeding further with the magnetic laws, that I define, as clearly as possible, those terms which we shall require a free use of in the examination of the causes that produce the deviations of the compass in iron ships.

The polarities of the magnetic needle are the first indications of energy which we may call magnetical force, magnetical energy, or magnetical influence. There is one point that we must endeavour to form as clear a conception of as possible. We have not as yet any clear definition of the terms "*polarity*," "*polarities*." These are generally understood to express two opposite forces, as attraction and repulsion. They have been defined by Dr. Whewell as *a contrast of properties corresponding to a contrast of positions*. In the first part of this definition we have still a difficulty to contend with, as we cannot well define or conceive of a contrast of properties. Of the latter we can form some idea, but we cannot well conceive of energy or motion being a contrast of positions; and it seems evident that, as long as we reason on energy being a property of matter, we shall still have to contend with those mechanical facts which will at all times stand in the path when we endeavour to reason the magnetical laws on mechanical principles. There is no good reason why we ought to regard energy or motion as a property of matter. Let us assume that the mechanical laws are correct, then let us discuss the magnetical laws on clearly defined mechanical principles.

Energy is a function; and its immediate indications in bodies depend on the atomical structure of the mass: thus two bodies whose energies are equal, the bodies are then equal to one another. When two bodies differ in energy, the one continues to absorb from the other until they become equal. Sensitive energy induces energy in all bodies within its sphere of action. When a body is acted upon by energy, a progressive change takes place in the structure of that body, the change being expansion or contraction; so that these bodies may possess active energy without indicating sensitive energy—this depending on the condition of the mass: energy in equilibrium is latent, when not in equilibrium it is sensitive.

The term polarity conveys to us an idea of energy or motion. The great question now is, Is energy or motion a property of matter? We think not, for we cannot well conceive of motion resting and then giving motion to itself, nor can we have the perception of matter giving motion to itself. It is true, we have many learned papers on the conservation of force into *vis viva*, but still we are without the answer to what is energy. One point seems plain—that is, we can form an idea of matter being passive till acted upon. In this view of the question we can reason all indication of energy or motion on clear mechanical deductions: then, let us fix in our mind the meaning of the term polarity and energy, and what we mean by them. Polarity we apply to matter, and believe it to be a certain condition or arrangement of the atomic mass of matter; and that matter, when acted upon by energy, is indicative of its influence—the amount of that influence depending on the arrangement or construction of the atomic mass. I know that the question may now be asked, What is energy or motion? Perhaps a blank line might convey as much on this point as any explanation I might offer in words. It is a question that seems for the time to be veiled; but I do know what I believe it to be—It is the parent of matter; it is the effect of an eternal and primary intelligent Cause; and its effects on inanimate matter constitute one of the great sources of our happiness in observing and studying its laws; but the question may be equally asked, and with as much reason, *What is matter?* Its ultimate basis or properties we know as little of as we do of the primary cause of motion. In our reasoning on matter we assume that the mass is formed of myriads of atoms; but we know well that this process of reasoning, when carried to an extreme point, leads us into mazes of difficulty, from which we discover how little we know, and how much we have to learn. It is not absolutely necessary for our purpose that we know from whence matter came, or the energies which bind and impel it throughout space; but we are permitted to observe and mark its various changes—this preparing us for higher and nobler purposes.

"All are parts of one stupendous whole,
Whose body nature is, and God the soul."

It is true our ideas of polarity are inseparable from the phenomena of magnetism, because it conveys to our minds equal and opposite powers or forces. This hypothesis leads us to conceive of atoms having poles which attract and repel each other, and was suggestive of atoms being surrounded by ethereal fluids. There can be no doubt but these views have gone far to assist inquiry, but they prevent us from reasoning beyond the circle. The polarity of matter seems to form the basis of magnetic action, by which energy is indicated in all its varied conditions. As I have said before, it is a power which we know only by its effects; it seems to be capable of action in all directions, moving inanimate matter by determined laws, which could not be sustained without a governing power to which these attributes belong. We can perceive its influence on the suspended prism assuming its equatorial position. This influence seems to be indicated by all substances, organic and inorganic. Similar affections are indicated by liquids and gases. From this it would appear that the magnetic energy seems to pervade all bodies, and that its action on matter, and its indications, depend on the arrangement or construction of the mass—the axis of motion depending on what we will call the polar arrangement of matter, so that energy is indicated by the mass in the same way as a ray of light may be indicated at different angles by a reflector, or as the optic axis of crystals—this depending on the internal polar condition of its prismatic arrangement. It would seem to be a law clearly indicated, from the experiments of Dr. Tyndall, that when the molecular structure of a body is such that the particles of which it is formed are in greater proximity in one direction than they are in another, the primary direction is the one in which the magnetic energy or force exerts itself with greatest influence. From the many adducible facts of the condition or arrangement of the atomic mass, they clearly indicate to us that those arrangements determine the direction in which the energy or force is to be indicated, in the same way as a reflector of heat or light may be adjusted to reflect from any degree of the circle; so that energy or motion may be as varied as a stringed instrument which gives forth a range of notes—their variations depending on the amount of tension, which tension affects the atomic arrangement of the wires.

Let us now assume that polarity conveys to us a certain condition of the atomic mass, which mass is pervaded by energy which continues to act upon it, the atomic arrangement indicating the lines of energy which may either impede or deflect that energy. From this view we can perceive that, by certain arrangements of the atomic mass, matter may be either compressed or repelled, thus giving an idea of gravity, cohesion, and expansion. From this view of the question we may have as many conditions of force indicated as the atomic form may have sides to reflect it. Assuming this hypothesis of energy acting on matter, all the conditions of force may be indicated as—

Central force is	Gravity.
Resisting force is	Inertia.
Elastic force is	Repellant.
Affinitive force is	Cohesion.

That we may, by analogy, form some idea of the polar magnetic indications, let us suppose we have three tubes of any convenient length, and that these tubes are so arranged that water or gas may flow through them (see annexed engraving), A, B, and C. It will be evident that, when the current is flowing through each tube, the upper ends, N, N, are the inducing or attracting, which also repel that of the fluid which they cannot receive, and the lower ends repel, in consequence of the discharge of the fluid, so that the tubes are in a condition of attracting and repelling. But suppose the current in the tube C to be reverse to the former, the current passing up this tube will then be in the condition of being attracted by B, as it will convey the fluid from S to N, thus

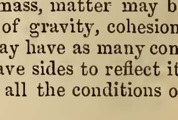


Fig.

equalizing each other's forces by a continuous current being formed. This, then, is similar to the effects of two magnets, the one force equalizing the other, although the magnet A would still maintain its condition of repelling B. Suppose these tubes to be transverse to the indicated current, it will be evident that the current would cease to flow, and that the attractive and repelling forces would cease to be indicated, although the flow might continue without that force heing indicated, this so far giving an idea of bars that are magnetised north and south, and those that are not, also of bars east and west.

I have endeavoured to show that magnetism may be reasoned on principles similar to that of the flow of a current. Then it would seem plain that, when we discover the set or flow of a current, we may use means to equalize that flow or set. We now come to the question, how are the magnetic currents induced? It appears clear that the induced magnetic power depends on the atomic arrangements of the mass, and that the magnetic influence may either bind or loose the atoms of matter. Induced magnetism may, for a time react against the great natural law, but the weaker current must ultimately give way to the stronger. To induce sensitive magnetism in a bar or plate of iron, the bar or plate must be rolled or hammered in a line with the magnetic meridian. By this means we induce a sensitive current of magnetism in the bar or plate. Also, if the bar or plate be suspended in the magnetic meridian, it will acquire magnetism by induction without physical action. Magnetism may also be powerfully induced by the galvanic battery.

That we may understand this more clearly, let us suppose that we clip or twist a strip of iron in the magnetic meridian, it immediately forms a magnet. Suppose that we clip or twist a strip of iron in an easterly or westerly direction, its magnetism is indefinite to polarity; thus clearly indicating that there is no current of magnetism from east to west to induce magnetism in iron. From this we observe that bars or plates which may be rolled, hammered, bent, or clipped east and west, will be comparatively free of magnetism, compared with those rolled or twisted north and south. This, then, so far assists us in reasoning on the deviations of the compasses in iron ships. Then let us keep clearly in view these leading facts, that we may draw clear deductions from them. Let us first examine the magnetic condition of the iron previous to its being used in the construction of the ship.

The rolling of the iron is the finishing process so far as the manufacturer is concerned; on the direction in which it is rolled and cut depends the strength of its magenetic condition. The direction in which the iron is rolled may be favourable to the arrangement of the atomic mass composing it. Bars or plates rolled in a polar direction will at all times indicate a greater flow of magnetism. From observations I have made in large iron manufactories, I have observed that iron, during the process of rolling, acquired an amount of magnetism, the quantity of that magnetism depending upon the direction in which it had been rolled; and the magnetism so acquired is not, in my opinion, at all times destroyed during the construction of the ship. The experiments of Dr. Scoresby on iron bars and plates, in reversing or changing their magnetism, demonstrate the power we possess by physical means of making the magnetic laws so far subservient to our designs in the construction of our ships; but while we keep strictly in view the utility of these experiments, we must be careful in our deductions when applying them to the building or construction of iron ships.

On entering a building-yard we observe the furnaces for heating the plates at one point of the compass, the tables for bending and twisting at another, and the machines for punching and boring at a third. From these varied positions we can observe ribs fixed to the ships's keel that would retain a greater amount of permanent magnetism than those hammered, bent, or twisted in an opposite position. I have found, from close observation, when a ship was building, the magnetism running in an easterly direction, and sometimes in a westerly, acting and re-acting, as beam after beam was fixed and plate after plate was rivetted; thus showing that those plates and ribs which were bent and twisted near to the magnetic meridian contained a greater amount of permanent magnetism than if they had been bent or twisted in an easterly or westerly direction. Again, if the upper end of each rib, post, or pillar, in a northern latitude, forms a south pole, except when previously charged by physical induced magnetism, the lower end of these forming north poles, the covering plates at times strengthen or weaken these influences. When the northern and southern magnetisms are permanent, and nearly balance each other, the indications of the compass are more correct, and are more easily rectified. The compasses of ships so balanced, in passing to a southern latitude, will indicate at all times more correctly than if either of the magnetisms had been predominant. This may be the reason why a few shipmasters are enabled to report favourably of the indications of their compasses in southern latitudes. I have no doubt that, when this subject comes to be fully investigated, it will be found that those compasses reported favourably of had never been much out.

Much has been said of late regarding the position in which ships ought to be built; but I know, from extensive observation, that the extreme deviations do not arise solely from the position or line in which the ship has been built; but much of it fram the direction in which the ribs and plates may have been bent, clipped, bored, or twisted, and also the direction in which the stern-post may have been forged; for I have known cases where it was forged in a reverse direction, when a strong northern polarity was induced to the top, which greatly modified the deviations of the steering compass. To the arrangements of the machinery for bending, cutting, and boring, the shipbuilder may have it in his power to construct his machinery in the most favourable position, but with the position of building he has little choice, as he must conform with the run of the water.

I know of building-yards which lie in a favourable position, and the deviations of the ships built there are small. This does not arise solely from the position of the ship. The bending, cutting, and boring is performed in an easterly and westerly direction. I have come to the conclusion that position is not the most essential point, as I know of some yards which are favourably situated as regards the position of the ship, but the bending, cutting, and boring are reversed to that of the former, and the deviations were nearly three times as great, so that I am inclined to believe that the position of the ship is not so important as that of the machinery.

I am in possession of upwards of 300 cards of the natural deviations of compasses, and they do not bear out position as being the main point to be kept in view. I have often observed in ships having two or three compasses, that their lines of no deviation were very different from one another. It is only a few months since two ships were built under the same shed and on the same lines, yet, when these ships were adjusted, the deviations in the one were double those in the other, and their lines of no deviation were equally different: this can only be accounted for by immediate local influences. I have no doubt, so far as the hull or shell of these ships is concerned, that those great natural lines may be very clearly traced; but in steamers, where there is such a quantity of iron introduced, those lines become bent out of their natural direction, and thus give to each compass a different line of no deviation; and numerous openings in the deck of a sailing ship give a similar tendency to distort the natural lines. From this we may so far reason, that if the compasses be under the dominancy of either of the polarities, the magnetic needle will be drawn towards that point: this disturbance may be equalised by a similar or opposite current. From this view of the question we can conceive of a series of currents repelling each other, and thus so far equalising the balance of the magnetic needle, if it happened to be suspended in the focus of the repelling influence; or it may be reversed by the opposite pole equalising the set of the magnetic current,—facts which will be discussed in the examination of this branch of the science.

I have stated that the strength of the magnetic condition depends much on the direction in which the iron has been rolled; and I am not altogether inclined to think that iron which readily indicates the flow of magnetism is of an inferior quality. This conclusion I have come to from extensive observation and practical experiments. Keeping first principles in view, it seems to be clearly indicated that the strength or flow of the magnetic current depends on a certain arrangement of the atomic mass composing the bar or plates; and this arrangement of the mass is induced by the bars or plates being rolled in a polar direction, which will at all times induce a free current of magnetism; and I believe that this atomic arrangement of the mass is calculated to improve the quality of the iron. It has been proposed to determine the quality of iron by its magnetic condition—that is, iron which indicates a free flow of magnetism is inferior. This may be doubted, as it will not at all times stand the test of observation and experiment; for we know from the latter that bars of steel which may be hardened near to the magnetic meridian will immediately indicate distinct polarity, and the bar which may be hardened east and west will be indifferent to polarity, and will never indicate a strength of magnetism equal to the former when both are magnetised by the galvanic battery.

Let us now examine the indications of the magnetic needle, that we may have a clear perception of the magnetic influence, from a steel bar which has been magnetised. Suppose it to be placed under a sheet of paper, and iron filings strewed over it; when the paper is gently tapped these particles form themselves into curves, taking a distinctive elliptical form, as shown in the annexed engraving; but if the magnet be held above the paper the effect is just the reverse. A bar or needle will at all times produce similar effects to the above. The first of those apparent

FIG. 7.

properties are attraction and repulsion. I have previously referred to these properties, and endeavoured to show that those apparent effects are the result of one great simple primary cause—the flow of energy; and it is only by a certain arrangement of the atomic mass that this energy is made apparent. Then it seems clear that this energy, in its indications, flows as a current. The question now is, What are the indications when a current flows? First, it sets in a particular direction, as north and south; then it must be evident that if a current were setting from south to north, the two currents must repel each other; if they be equal, an equilibrium is the result, and the energy for the time appears suspended. This, so far, gives us an idea of the principles of repulsion and energy.

Again, suppose one portion of the matter which energy has acted upon to undergo an atomic arrangement in consequence of the dominancy of one of the currents, it is evident that the flow of the current would be unimpeded, and that which repelled would now attract the former, and the flow of energy would follow the same course: thus, attraction and repulsion are only the material atoms impeding the primary flow of energy. On referring to the engraving, the arrangement of the particles, forming distinct elliptical curves, convey to us an idea of lines of energy completing their current, and returning to flow again in the same direction.

From the engraving it will be observed that one of the magnets is represented much larger than the other, and the pole of the smaller is repelling; but the dominant power of the larger would ultimately reverse the poles of the smaller, so that their magnetic currents would set in the same direction; thus giving an idea that poles, when dominant, may change the set of the magnetic current to any point of the compass.

Fig. 8.

Then, let us inquire what our experience and observations are on board of an iron ship. In the first place, in ships that are built in northern latitudes, the top of each rib or pillar forms a strong south pole, the plating and beams occasionally weakening or strengthening the flow of magnetism, so that the current of magnetism on a ship's deck may be likened to a series of winding currents and eddies. The annexed engraving represents the outline of a ship's deck, and also indicates the position of 1, 2, and 3 compasses, M M, masts, A, cabin skylight, B, a hatch. It will be observed that the darts on each compass represent the direction of the magnetic needle at the different points on the ship's deck, and thus give an idea of the flow or set of the magnetic currents in the different positions. Then it must be evident that if we find the set of the magnetic current, we may equalise that current by a similar power; thus for a time inducing an equilibrium, that the compasses may indicate correctly. That the magnetic currents on a ship's deck may be better understood, let us suppose the current setting in any particular direction, as N.E., and that current inducing a deviation equal to one point at north, the other points following in a similar proportion. We know by practical experiment that, when we discover the magnetic set of the current, we can experimentally produce similar deviations by placing a magnet to an isolated compass, and thus induce similar deviations to those indicated by the compass on ship's deck. If we can do this experimentally by one magnet, we must then have the power to correct it by placing a similar magnet parallel with the former, taking care to place the magnet so that the set of its current may run in the reverse direction; the two currents would thus equalise each other, and the compass would indicate freely. This may be better understood by the annexed engraving. The circle represents the outline of a compass, the magnet A the set of the disturbing current, the correcting magnet B the set of the magnetic current reverse of A, as indicated by the darts; thus the two forces equalise each other, and the compass indicates freely. This will be evident when we come to examine the compass deviations in the various ships.

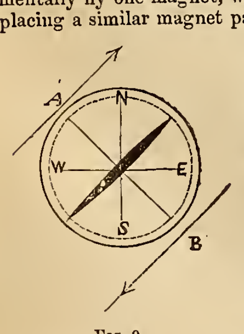


Fig. 9.

It is now generally admitted that, in an iron ship passing from a northern to a southern latitude, what we term the natural deviations undergo a considerable change. The amount of that change depends much on the original deviations—*i.e.*, when the deviations are small the change will be in proportion; but in ships where the deviations are great, the change will be in a similar proportion.

If the adjustment of the compass by a single magnet be a fact that we can demonstrate, then it is not necessary that a combination of magnets be used. With the single magnet there are many advantages. If the natural deviations be induced by a magnetic current setting in a particular direction, by placing the correcting magnet so that its current might set in the opposite direction, the two currents meeting would form an equilibrium, and the compass would be free to indicate. With this view of the question the commander would be able to assist himself in passing from a northern to a southern latitude. It will be evident that the principle resolves itself into two contending forces: the commander having the power of one—the magnet—he may use it for counterpoising the other—the magnetism of the ship. By following this principle, he has the power to approximate his compass as near to the point of correction as may be possible. This principle cannot be applied where a combination of magnets is used.

NOTES OF ENGINEERING PROGRESS IN ITALY.

Mechanical industry and engineering in general has been continually on the increase in Italy for the last five years. It appears, from a statement in the "Giornale dell'Ingegnere ed Architetto," that Italy is now capable of providing for her own engineering wants. Liguria, and more particularly Genoa and its environs, are at present the chief centres of mechanical industry in Italy. The most important establishment is the San Pier d'Arena Works, near Genoa, conducted by Orlando Brothers. At these works, some 600 operatives are employed, 150 of whom are engaged at the foundry; about 20 locomotives have hitherto been constructed there. Three large steam hammers are at work in this establishment, and a line of railway, for the use of the firm, connects the works with Turin and Liguria. At Robertson's works, also near Genoa, some 130 workmen are employed. They supply turbines, steam engines, mills, &c. At Orlando's works, Porta Pisa, some 300 workmen are employed, in the manufacture of marine engines, iron bridges, &c., the value of their products amounts to about £24,000 per annum. Werstermann Brothers, at Sestri di Ponente, employ 150 workmen in the manufacture of turbines, steam engines, &c. At Balleydier's Foundry, San Pier d'Arena, 200 operatives are employed, and about £20,000 worth of castings are produced per annum. Amongst engineering establishments in Piedmont are Molinari's, in Bisagno; Decker's, in Turin (100 operatives); Colla's foundry, with 200 workmen; and Huguet's turbine factory.

In Milan alone, there are 26 factories. The most prominent factories are:—Bouffier's at Milan, for the manufacture of gas apparatus; Suffert, machinery for the manufacture of silk; Schlegel and Co.'s, founded in 1851, employ 400 workmen and a driving engine of 54 horse-power; Bartolon and Co., at Treviso, employ 150 workmen and a hydraulic force of 200 horse-power; Benech and Rocchetti, at Padova, construct iron bridges, steam engines, &c.

BOOKS RECEIVED.

"A Treatise on Sugar Machinery," including the process of producing sugar from the cane, refining moist and loaf sugar, home and colonial, the practical mode of designing, manufacturing, and erecting the machinery, together with rules for proportions and estimates. Illustrated by four single and twelve large folding Plates. By R. P. Burgh, Engineer. London: E. and F. N. Spon. 1863.

"A Practical Treatise on Limes, Hydraulic Cements, and Mortars." By Q. A. Gillmore, A.M., Brigadier-General of U. S. Volunteers, and Major of U. S. Corps of Engineers. New York: D. Van Nostrand, 192, Broadway. London: Trubner and Co. 1863.

"A Pocket Book of Useful Formulæ and Memoranda for the use of Civil and Mechanical Engineers." By Guilford L. Molesworth, Memb. Inst., C.E. A Fourth Edition, with a Supplement. London: E. and F. N. Spoon.

"The Ghost," as produced in the Spectre Drama, by Henry Dircks, C.E., the inventor. London, E. and F. N. Spon, Bucklersbury, 1863.

[The unavoidably limited space at our command in the present number necessitates our deferring until next month the reviews which we have prepared of the above valuable books and treatises.—Ed. Artizan.]

NOTICES TO CORRESPONDENTS.

J. H. (Nottingham).—We are in receipt of your communication and will give place to the subject, if possible, in our next issue.

"Young Engineer."—You will find, on reference to The Artizan of December last, a description of the several preparations which have been employed for covering iron plates to prevent decay.

Alpha.—Send us your address in Hartlepool, that we may answer you by post, and advise you through The Artizan Patent Office upon the questions you put.

D. R. (Dumfries).—The particulars you want shall be sent you from The Artizan Patent Office. With reference to the sketch you have sent us, we shall be glad to know what *your* opinion is as to the advantages which you consider possessed by your plan as compared with previous contrivances for effecting the same object.

RECENT LEGAL DECISIONS

AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

UNDER this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

LANE *v.* STERNE.—Mr. Bacon, Q.C., and Mr. Prendergast appeared in support of a motion to restrain the London, Chatham, and Dover Railway Company from interfering with the possession of the receiver appointed by the Court of the partnership property of the plaintiff Lane and defendant Sterne until such receiver should have had time to sell the stock in trade on the partnership premises. The plaintiff and the defendant carried on the Borough Steam Wheel Works in partnership, and this suit was instituted for its dissolution. In September last the company interfered with the possession of the receiver, upon which an application was made to the Master of the Rolls, as vacation Judge, for a sequestration against the company as for contempt, but an arrangement was then come to, which was embodied in an order, by which the company were to be at liberty to take possession of the works on the 5th of October, on condition that they should, on or before the 17th of that month, pay into the bank £8400, which they did. The value of the property taken by the company was subsequently assessed at £7559. The company now insisted upon their right to take possession of part of the premises in which the stock in trade was deposited, and the parties interested therein contended that they should have time to sell before the company entered into possession. Mr. Malins, Q.C., and Mr. Renshaw, for the company, contended that as they had paid the purchase-money into court, they were entitled to possession. The Vice-Chancellor said that when the order of September was made, it was agreed that a reasonable time should be allowed for the removal of the stock in trade. The Court could not allow the property of which it had taken the charge to be injured. There must be a reasonable time allowed for the sale of the stock in trade, and the order would be that the company should be restrained from using their possession so as to interfere with such stock in trade. The receiver must also be ordered to sell the same with all convenient speed, with liberty to apply.

GERISH *v.* BERNSTINGL.—The plaintiff, an engineer and ironfounder, carrying on business at East-road, Hoxton, sued the defendant a photographic artist, in Regent-street, to recover the sum of £55 for making a lift and fixing the same on defendant's premises. The defendant's photographic rooms being at the top of the house as usual for the purpose of obtaining the light, it occurred to the defendant that it would be an accommodation to his customers if the fatigue of climbing up the stairs could be avoided, and he put himself in negociation with the plaintiff, who has been accustomed to make lifts, or small ascending rooms, wound up by chains and machinery from below to any required height, for houses in the city. The plaintiff, in February last, agreed to make a lift for the defendant for £50, and the extra £5 was for cutting away brickwork, &c., in order to fit the same. The lift was made and fitted, and tried, and found to work, six persons being elevated thereby to the photographic room. The defence to the action was that the lift was so defectively made as to be useless, and incapable of being worked easily, and that the plaintiff had been required to take it away, and that it was now at the defendant's premises only a nuisance. The evidence, on the part of the defendant, was to the effect that though a person might be raised up to the defendant's room, yet it was by a series of jerks. The jury ultimately found a verdict for the plaintiff for £55, the learned Judge reserving leave for the defendant to move to reduce the amount of the verdict upon a point of law.

TROTMAN *v.* WOOD AND OTHERS.—The plaintiff is the inventor of the improvements in the well-known and celebrated Trotman's anchor, and the defendants are anchor manufacturers of Liverpool and London. This action was for an infringement of the plaintiff's patent, and the defence was that the anchor in question, made by the defendants for the Pasha of Egypt's yacht, was not an infringement of Trotman's patent. The defendents did not deny the validity of the patent, for, on the contrary, they had obtained a licence from the plaintiff, and worked under it, but they contended they were still at liberty to make other anchors which were not an infringement of the patent, of which they said the anchor in question was one, without paying the royalty. The plaintiff described one of the main features of his patent to be the making or fixing the palms at the back of the arms or flukes of anchors, which move on axis, and that the defendant had done this in the anchor in question. The defendants, on the other hand, contended that they had merely followed the pattern of the old Dutch anchor, in which the palms were either in front or at the back of the arms or flukes according to the will of the maker. After hearing both sides, the jury found a verdict for the plaintiff.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

CANADIAN PACKETS.—The new contract between the Government and the Montreal Ocean Steamship Company has been signed by the Postmaster-General, subject to the approval of Parliament. The contract is for five years. The amount payable by Government is £54,500 currency (218,000 dollars) per annum. The contract provides that the vessels shall slacken speed or stop whenever danger is feared from fog or icebergs; and time thus lost is not to be regarded as a default on the part of the contractors. It ha also been very properly made a condition of the contract that the steamers shall not approach Cape Race in bad weather.

THE EXPORT OF IRON TO FRANCE.—The export of iron to France has considerably fallen off for the 1863 year, as compared with 1862, although the deliveries of pig-iron in the same direction have been pretty well maintained. Thus the value of the iron imported into France during the first ten months of 1863 was only £174,238, against £324,774 in the corresponding period of 1862. The value of the pig-iron imported during the first ten months of 1863 was £638,428, against £755,421 in the corresponding period of 1862. The great falling off in the importation of iron is due to the fact that prices in France have not followed the rise established in England and Belgium, and therefore a profit cannot now be obtained upon deliveries to French ports.

THE LONDON COAL TRADE.—In the month of November last the various railways having access to London, brought 183,015 tons 16 cwt. against 151,819 tons 5 cwt. for the corresponding month of 1862. For every month of the present year, without a single exception, the coal traffic by railway has increased, and for November the additional traffic, as compared with 1862, is not less than 31,196 tons 11 cwt. The London and North-Western has carried 89,688 tons 9 cwt.; Great Northern, 61,223 tons 18 cwt.; Midland, 9,977 tons 8 cwt. to St. Pancras station, and 2,653 tons 16 cwt. to King's-cross—total, 12,631 tons 4 cwt.; Great Eastern, 12,075 tons 10 cwt.; Great Western, 6,566 tons; London, Chatham, and Dover, 332 tons 8 cwt.; South Western, 379 tons 7 cwt.; and London and Tilbury, 69 tons. Of the London and North-Western tonnage, 15,100 tons were from Clay-cross Pits, near Chesterfield; 7,247 tons 15 cwt. from Ince Hall, Wigan; 6,541 tons 5 cwt. from Kirkless Hall; 5,167 tons 18 cwt. from Staveley; 4,065 tons 10 cwt. from Pinxton; and 3,769 tons 8 cwt. from Baddesley. The Great Northern includes about 20,000 tons (in round numbers) of Silkstone; 3,180 tons 19 cwt. from Gawber Hall, and 3,076 tons 10 cwt. from Staveley. Seaborne coal for the month has been 302,734 tons against 323,889 tons for the same month of 1862. From Newcastle there has been entered 120,647 tons, in 277 ships; Sunderland, 96,790 tons, in 219 ships; Seaham, 15,346 tons, in 59 ships; Hartlepool, and West Hartlepool, 48,900 tons, in 165 ships; Middlesborough, 6,783 tons, in 21 ships; Blyth, 2,216 tons, in 8 ships; Scotch, 1,878 tons, in 10 ships; 5,029 tons of Welsh, in 14 ships; Yorkshire, 1,765 tons, in 24 ships; 2,593 tons of small coal, in 5 ships; and 807 tons of cinders, in 5 ships. For the 11 months of the present year the seaborne traffic has declined by 753 ships, and 98,706 tons, the total being 8,771 ships, with 2,995,642 tons in 1862 against 9,524 ships and 3,094,348 tons in 1863. This decline, however, is more than counterbalanced by the very great increase in the railway traffic.

STEAM CULTIVATION OF LAND.—A public meeting of persons interested in agricultur was held on the 19th ult., at St. James's Hall, for the purpose of considering the best mode of extending the application of steam power to the cultivation of the soil. About 120 gentlemen were present, including the Earl of Suffolk, Lord Berners, Lord R. Montagu, M.P., Sir G. Jenkinson, Sir H. Vavasour, &c. Mr. Holland, M.P., presided, and having briefly stated the object of the meeting, proceeded to point out the advantage of cultivation by steam, especially upon heavy clay lands, where the pressure of the horses' feet causes almost as much damage as the plough they drew did good. Having himself employed steam for four years, he could distinctly speak of the advantages of the system. Instead of 20 working horses he now only keeps 12; and another advantage was that in the autumn as much ploughing could be done in one week as would take five or six weeks to do by horse power. In fact, upon clay lands steam had worked a complete revolution, having converted them from a state of semi-productiveness into something like kitchen-gardens. It was necessary to consider what were the reasons why so advantageous a system had not been universally adopted, and, in the first place, he thought landlords did not yet appreciate the great merits of steam-ploughing, and therefore it was that small fields were retained. The cost of a steam-plough and machinery—in his own case about £1000—was a heavy demand upon a farmer's capital. Local associations to lend out machinery had been found unsuitable; and it had been considered that the best mode of extending the system of steam cultivation would be to establish a joint-stock company to purchase machinery for farmers, receiving repayment by instalments spread over a term of years. Lord R. Montagu moved a resolution affirming the advantages of steam-cultivation, and supported it by reference to the published opinions of Mr. Smith, of Woolston, and other experienced agriculturists, as to the superiority of steam to horse power in the cultivation of the soil, both in point of cheapness and of increased production. Mr. Williams, of Abingdon, seconded the resolution. A conversation arose, in the course of which Mr. Brooke, a landowner and farmer in Suffolk, expressed a doubt whether the superior merits and relative cheapness of steam cultivation had yet been sufficiently proved. The resolution was adopted, as was also another proposed by the Earl of Suffolk, declaring the great obstacle to the progress of steam cultivation to be the inability of tenant-farmers generally to purchase expensive machinery. Mr. Beavis, a tenant-farmer, declared that the body to which he belonged were quite as ready to adopt new methods, when satisfied that they would pay, as were the manufacturing body, and that he should be very glad to use steam power, if ploughing by it could be done for 10s. per acre. Other resolutions were adopted, approving generally of the formation of joint-stock companies to assist tenant-farmers in the purchase of steam apparatus, and specially of the particular company in support of which the meeting had been called. Dr. Voelcker, the distinguished agricultural chemist, who spoke in support of the resolutions, stated that there were some soils which could only be made available by steam cultivation, the adoption of which would therefore be a national benefit. A gentleman present gave some details as to the successful working of steam-ploughs and cultivators upon the sugar plantations of Antigua, Demerara, and Barbadoes; and after some further general discussion the meeting was brought to a close by the usual vote of thanks to the chairman.

NEW ACT ON PUBLIC COMPANIES.—An Act was passed in the last session, which will practically take effect in the next, to consolidate in one Act provisions frequently inserted in Acts relating to the constitution and management of companies for carrying on undertakings of a public nature. The Act is divided into four parts, and treats of the cancellation and surrender of shares, additional capital, debenture stock, and the change of the names of companies. A company may cancel forfeited shares, and may enforce payment of calls in arrear, notwithstanding the cancellation. A company may accept on terms the surrender of any shares which have not been fully paid up, but a company is not to pay any money for or in respect of the cancellation of shares. By this Act any misused stock or share may be cancelled.

BRAY'S TRACTION ENGINE COMPANY has received from the Russian Government an order to manufacture several of the traction engines and carriages, similar to that in use at Woolwich Dockyard, for the removal of timber and heavy loads.

LARGE CASTINGS.—Four castings in green sand, of unusual magnitude, have recently been successfully made at Messrs. Hicks and Sons', Soho Ironworks. Two comprised a press top and bottom for Government, each weighing twenty tons. Another was part of an anvil block, weighing twenty-five tons, and the fourth was the remaining part of the anvil block, weighing forty-two tons. This anvil block was made for the use of the Bolton Steel Company. The metal was poured into the moulds from enormous ladles, in presence of a large concourse of spectators.

DRAINAGE OF BOMBAY.—The Municipal Commissioners for Bombay have, with the sanction of the Indian Government, recently carried a "resolution" to "sewer and drain Bombay," at an estimated cost of "three hundred and thirty-five thousand pounds."

The "proposition" for the "main drainage of the native town and fort of Bombay" has been devised and matured by Mr. H. G. Wilcox, surveyor to the Municipal Commissioners; Mr. W. Tracey, assistant surveyor; and is dated 1st December, 1860. The population provided for is one million residents. The scheme will be partly gravitating and partly by pumping. Early in last year (1863) the whole of the reports, plans, papers, and estimates were submitted by the Indian Government to Mr. Robert Rawlinson, C.E.; and in April of last year Mr. Rawlinson sent in his report, recommending that the plans and estimates of Messrs. H. G. Wilcox and W. Tracey (with certain modifications, as set forth in his report) be approved. In September, by resolution of the Local Government of Bombay, the plans so approved were "ordered to be carried out,"—"Mr. W. Tracey to be executive engineer; Captain Trevor to be consulting engineer."

Treatment of Steel and Iron.—Some improvements have been patented by Mr. Robert Mushet, of Coleford, which consist in thoroughly mixing, without the agency and deteriorating effects of the pneumatic blast, melted spiegeleisen or other metallic alloys, such as alloys of tungstein and iron, or of titanium and iron, with melted steel or malleable iron, prepared by the pneumatic process from melted pig-iron or cast-iron, and this he effects either by the use of two pneumatic or decarbonising vessels, both containing melted steel or malleable iron made by the pneumatic process, to the steel or malleable iron, in one or both of which two vessels the melted spiegeleisen or other melted alloy has been added, the contents of one vessel being poured into the other vessel, so as to ultimately mix and make the whole of uniform composition. Or by the use of one working pneumatic vessel, or of two or more such vessels in which the metal to be operated on has been produced, and another or supplementary vessel, which previous to use has been intensely heated, in this the melted spiegeleisen and the melted iron or steel is mixed. The same gentleman has also patented an invention for casting steel or homogeneous iron in moulds made wholly or chiefly of wrought-iron.

Dressing Slates.—A peculiar combination of machinery for dressing slates, whereby economy of construction, with efficiency and rapidity of motion are obtained, has been provisionally specified by Mr. Henry Williams, of Portmadoc. According to this invention, it is proposed to employ a horizontal knife, or knives vibrating, vertically, so as to receive a chopping motion. The knives are carried on arms keyed to a horizontal rocking-shaft, supported on bearings fixed to the main framing of the machine. A rapid rocking motion is imparted to this shaft by means of a revolving crank-pin carried on the end of the main driving shaft, and working in a slotted lever arm keyed to the rocking-shaft, or by means of a connecting rod worked by an eccentric. The driving shaft is supported on suitable bearings on the main framing, and is provided with the usual fast and loose driving pulleys. The machine is fitted with the usual gauge and travel.

Photographs of the Moon.—Mr. Warren De la Rue has presented to the Académie des Sciences two photographic views of the moon, of 95 centimetres (3ft. 1½in.) each in diameter. On one of the impressions, the defects derived from the enlargement or the application of collodion have been mended, whereas the other has not been touched up at all; however, the difference between the two impressions is hardly perceptible. These views were taken by enlarging 36½ times the original negatives taken by Mr. De la Rue, at a size of about 2 centimetres (0·8in.) The method followed is a very simple one: he places the small negative before the focus of the objective, and takes the enlarged view behind. Twelve impressions have been pulled from the latter; they are all intended to be presented to academies and public establishments.

New Lighthouse at Arranmore, in Ireland.—A new lighthouse has been completed at Arranmore at an expense of close upon £10,000. The structure is of granite. Messrs. W. Crowe and Sons, of Dublin, were the contractors. The lamp to be erected is the first that has been constructed by an Irish establishment. Messrs. Edmondson and Co., of Dublin. The new light is to be a flash-revolving one of the first class.

Reacting Printing Machine.—Messrs. Perreau and Co., engineers of Paris, employ reacting printing machines, with six rolling cylinders instead of four, and cause the two central ones, right and left of the machine, to be fed by one layer only. For this purpose, they apply to the upper laying table a mechanism which allows that table to take the sheets alternately to one or the other of the laying rollers. This table is set in motion, in strictly regular intervals, by two cogs symmetrically mounted on the extremities of a shaft, which is moved by a set of gearings. The arrangement of the cords which guide the sheets is such, that two sheets (laid by the same man on both central cylinders), may be withdrawn through the same aperture and by one man only. For the lower cylinder the usual arrangement is preserved. The advantage arrived at by means of these machines is reported to be the printing of 8000 instead of 6000 papers per hour, printed by those machines now in use in Paris; moreover, no alteration in the forms or no increase of the staff is required.

Cotton Culture in Italy.—The trials made by Count Gori last year, on his estates of La Valdischiana, in the province of Siena, have been very successful. Although the sowing took place only in the first days of May, the pods were ripe in the first days of November, and the cotton that has been gathered is reported to be as fine and white as American. From Sicily 2,814,838lbs. were exported in 1863 to France and England.

Petroleum.—American rock-oil is now exported to almost every quarter of the globe. From the 1st of January until the close of October, 1862, there were 5,195,481 gallons shipped from New York alone. For the same period of the past year, New York has imported 15,503,166 gallons; Philadelphia, 4,268,244 gallons; Boston, 1,604,846 gallons; Baltimore, 806,961 gallons. In round numbers, the total value of the exports from the ports above named, from January 1 until the close of October, 1863, will not fall short of 10,000,000 dollars.

NAVAL ENGINEERING.

Mr. Martin's Patent Anchor, which was proved under the hydraulic testing machinery at Woolwich on the 12th ult., for service on board the flagship *Edgar*, was on the 14th ult. submitted to a most severe fire proof. The parts of the anchor were taken to pieces, placed in separate fires, and heated to a low red heat. Each section was examined and searched over with the most scrupulous care, in order to discover any signs of weakness or flaw in the metal. The cheeks and other portions of the anchor subject to the greatest amount of strain were filed over, and the surface was chiseled off where any scratches were perceptible. The chips were then put through a course of inspection by Mr. Wilcox and his assistant smiths, but no blemish or imperfection could be detected. The anchor was thereupon pronounced fit for the service for which it was intended. Admiral Sir Montague Stopford, chairman, Mr. Maturin, manager of the works, and other members of the company were in attendance. Arrangements are in progress for the erection of premises near Charlton-pier, in the vicinity of Woolwich Dockyard, for the manufacture of the anchors, 600 of which, it was stated by Admiral Stopford, have been already supplied to the mercantile navy, the whole of which are of acknowledged excellence.

The Russian Fleet.—From an official list we gain the following information:—The Russian fleet consists at present of—Steamers: 9 screw liners, 12 screw frigates, 8 paddle frigates, 22 screw corvettes, 12 screw clippers, 1 iron-clad battery (and 12 more building), 1 iron-clad schooner, 79 screw gun-boats, 2 screw yachts, 34 screw schooners and transports, and 68 smaller paddle-steamers, total 248, with 37,007 horse-power, and 2387 guns. Sailing vessels: 9 line-of-battle ships, 5 frigates, 3 corvettes, 3 brigs, 13 schooners, 2 gun-boats, 2 tenders, 13 transports, 12 yachts, total 62, with 1304 guns; grand total, 310 vessels, with 3691 guns. The personnel consists of: 93 admirals, 3038 staff and other officers, 376 cadets and conductors, 989 civil service officers of the navy, and 49,405 non-commissioned officers and men.

The "Conqueror," screw steam line-of-battle ship, 78 (late *Waterloo*), 2845 tons, 500 horse-power, steamed on the 11th ult. from her moorings in the harbour to the measured mile off Maplin Sands, for the final trial of her engines, preparatory to leaving for Plymouth. The vessel was in charge of Capt. W. K. Hall, commanding the Sheerness steam reserve, and the chief engineer of the ship superintended the working of the machinery. Six runs were made at the measured mile at full speed. The following were the results:—An average speed of 9·395 knots; the revolutions of engines, *maximum* 62, mean 60·5 per minute; pressure of steam, 18lb.; vacuum, 25lb.; draught of water during the trial, forward, 23ft., 3in., aft. 26ft. 4in. The engines are built by Messrs. Ravenhill, Salkeld, and Co., and are fitted with Griffiths' screw, diameter, 18ft., pitch, 20ft., immersion 5ft. 10in. There was a strong breeze blowing from north-west, the force of wind being from 6 to 7, and the sea rough. The trial was considered to be very satisfactory.

The "Wasp," 17-gun screw corvette, 100 horse-power, on the 11th ult., made her final trial of speed at the measured mile in Stokes Bay, prior to sailing on foreign service. The ship drew 14ft. 7in. of water forward, and 15ft. 5in. aft. A mean speed of 6·701 knots was attained. The revolutions of the engines ranged from 60 to 62.

A Steam Gunboat in Sydney has been completed for the New Zealand Government for service on the Waikatoo or elsewhere. She is of iron:—Length, 140ft., breadth, 20ft., and depth only 8ft. With stores, arms, and 300 men, she will only draw 3ft., or not over 3½ft. of water. In case she should be required to put to sea, as she will be in moving from one place to another, she has a shifting keel. Her engines are of 40 horse-power, of improved construction, and she is propelled by a single paddle-wheel astern, with feathering floats. This is well defended by an iron casing. She has two iron towers as they are called—one between the main and mizen masts and one between the foremasts and stem. They are circulars, 12ft. in diameter, and 8ft. high, and are pierced with loopholes for rifles, and ports for 12lb. Armstrongs. The engines are below the main decks, and the commander, engineers, and helmsman are protected. From the two towers she can be raked fore and aft, should boarders reach her decks; but before they could do that they would be met by a very unpleasant assailant. She is furnished with perforated pipes along her side, from which jets of boiling water can be directed against assailants. From the towers the smoke of her guns is expelled by a fan, and she carries coal for seven full days' consumption.

The "Warrior."—The consumption of coal on this iron-clad from July 11 to October 3, from the time of leaving Spithead at the commencement of the recent cruise until anchoring in Plymouth Sound at its conclusion, for the various purposes, was as follows:—Lighting fires and getting up steam, 186 tons; keeping fires banked, 35 tons; in evolutions and experiments, 82 tons 10 cwt.; distilling waters, 72 tons; culinary purposes, 21 tons 5 cwt.; keeping station with squadron, 563 tons 10 cwt. The total expenditure was thus 962 tons 5 cwt. The number of hours the fires were lighted was 1406; the number of hours the steam was up, 605; the number of hours the screw was actually working, 341; the total quantity of fresh water distilled in gallons was 127,000; the total distance the ship went in knots, by log, was 2,286: the *maximum* power of engines exerted was, 3186 horse-power; and the *minimum*, 73·5; the number of days at sea was, 35. The most striking feature in these figures is the reduction of the working power of the monstrous engines of the *Warrior* to 73 indicated collective horse-power, the engines at the time making 10 revolutions, and the ship going 2⅞ knots.

Naval Appointments.—The following appointments have taken place since our last—T. Duncan, chief Engineer, to the *Conqueror*; S. E. Derrick, W. W. Christie, and H. Benhow, Engineers, to the *Euryalus*, additional for disposal; H. Knight, Engineer, to the *Cornwallis*; F. W. Sutton, Acting Engineer, to the *Cornwallis* tender; J. Martin, Acting Engineer, to the *Hawke* tender; A. Stewart, (a), R. Glasspole, J. Rogers, A. H. Rogers, T. Haywood, H. A. Palmer, M. Harris, J. Roberts (b), and E. L. Williams, Assist. Engineers, to the *Euryalus*, additional for disposal; P. Blanch, A. Reid, and W. Vaudrey, Assist. Engineers, to the *Conqueror*; C. Hetherington, of the *Marlborough*; J. R. Cooper, of the *Cumberland*; T. Wilson, of the *Fisguard*; W. Young, of the *Rattler*; D. Landlands, of the *Caradoc*; J. Roberts (b), of the *Euryalus*; D. Miller, of the *Majestic*; T. Edgar, of the *Phœbe*; J. King (a), of the *Hydra*; A. Smith, of the *Psyche*; and E. Hawke, of the *Charybdis*, promoted to Engineers; W. Sides, of the *Curlew*, promoted to Acting Engineer; J. S. Hill, Engineer, to the *Zebra*; G. F. Ball, Engineer, to the *Edinburgh*, for the tender; W. Hardie, Engineer, to the *Hague*; J. Battison, Acting Engineer, to the *Hastings*, for the *Advice*; J. Meiklejohn, Assist. Engineer, to the *Ajax*, for the tender; J. Forrest (a), T. Bramley, J. Hansford, D. Leitch, W. A. Batts, T. Coombes, E. L. Carte, and J. Shiel, Assist. Engineers, to the *Rattlesnake*, as Supernumeraries; E. O. Crichton, Chief Engineer, to the *Asia*, for the *Duncan*; L. Swift, Chief Engineer, to the *Asia* for the *Victor Emmanuel*; J. Hurd, H. W. Thompson, and J. Hunter, promoted to be First-class Assist. Engineers; M. Roger, Second-class Assist. Engineer, to the *Conqueror*; M. Barker, Engineer, to the *Russell*; J. M'Kenzie, of the *Asia*, J. Mutter (acting), of the *Challenger*, A. M'Intyre, of the *Cumberland*, G. E. Foote (acting), of the *Terror*, D. Francis, (acting), of the *Vulcan*, J. Aitkin, of the *Fox*, W. Wallan, of the *Queen*, D. Cartmel (acting), of the *Immortalite*, J. Turner, of the *Asia*, for the *Hector*; R. Anderson (b), of the *Himalaya*, J. B. Frith, of the *Argus*, G. Bartlett, of the *Magicienne*, and T. Young, of the *Industry*, promoted to be First-class Assist. Engineers; H. S. Pemberton, Second-class Assist. Engineer, to the *Edgar*; B. Barber, chief Engineer, to the *Salamander*; J. R. Cooper, Engineer, to the *Congeuror*; J. West, Engineer, to the *Asia*, for the *Tyrian*; J. Orchard, Engineer, to the *Salamander*; J. W. Baron, First-class Assist. Engineer to the *Euryalus*; W. Brenner, Second-class Assist. Engineer to the *Salamander*; F. Hewson, H. M. Miller, J. W. East, L. M. Croke, A. H. Alston, P. R. Sharpe, P. H. Colomb, R. Wells, and E. W. Brooker; J. Watts and S. B. Williams, Assist. Engineers, to the *Conqueror*; O. L. Carlisle, Chief Engineer to the *Orestes*; H. W. Tregilgas, late of the *Algerine*, confirmed as Engineer; J. Sanders, Chief Engineer to the *Fisgard*, to the *Minotaur*; J. W. German, Chief Engineer to the *Asia* for the *Termagant*; M. Harris, supernumerary in the *Euroyalus*, confirmed as First-class Assist. Engineer; J. Hawkins, Second-class Assist. Engineer, to the *Salamander*; R. Drummond, Chief Engineer to the *Indus*, for the *Topaze*, when the latter ship is paid off; M. Blank, Assist. Engineer to the *Fisgard*, as supernumerary, and granted two months' leave; J. Jolliffe, Acting Engineer, and J. Muir and J. J. White, Assist. Engineers to the *Lyra*.

MILITARY ENGINEERING.

At Portsmouth a Trial of Armour-plates took place on the 14th ult., at the practice range in Porchester-creek, the plates being affixed to the side of the target-ship with 2in. through holts, and the shot (cast-iron) being fired against them from a 68-pounder gun on the deck of the *Foam* gunboat, at 200 yards' distance. The plates were supplied by the firm of Messrs. Beale, Parkgate Works, Yorkshire; the Thames Ironworks and Shipbuilding Company; the Mersey Ironworks, Liverpool; and Messrs. J. Brown and Co., Atlas Works, Sheffield. They were of various thicknesses. The plate sent in by Messrs. Beale was rolled but "surface planed" (according to the established regulations of the Admiralty) from 4½ to 4⅛in., the skin of the plate being thus destroyed and its fibrous strength damaged. The Mersey plate was of hammered manufacture and of an uniform thickness of 5⅛in. It was severely pounded by clusters of shot at the extremities, and on its left end the plate exhibited several large cracks, apparently caused by the defective state of that part of the ship's side which formed its "backing." The Thames plate was also hammered, and was from 3⅞in. to 3⅝in. in thickness of metal. Being of hammered manufacture it possessed, like all other hammered and tapered plates, the ad-

vantage over Messrs. Beale's tapered plate that its thickness was worked down under the hammer, its skin and fibre being thus left intact in all their rough strength and not partially destroyed by the application of the planing tool, as must necessarily be the case with all tapered rolled plates under their present conditions of manufacture. The Thames Company's plate stood the impact of the 68-pounder admirably, considering its thickness and the absurdity of testing a 3¾in. plate with the same gun, weight of shot and powder that were used in the test of the 5½in. plate. As, however, these trials are carried on merely to enable the Admiralty to classify and thus obtain a knowledge of the exact quality of the plate's metal and manufacture, the use of one description of gun may, possibly, not seriously affect the results, when the trials are conducted under duly experienced officers. The fourth plate under trial, sent in by Messrs. John Brown and Co., of the Atlas Works, Sheffield, was of rolled make, and of an uniform thickness of 4in. The foregoing remarks therefore apply to its trial by the 68-pounder in a certain ratio, according to the difference between its thickness and that of the now established standard of 5½in. plate. This 4½in. plate, however, withstood the shot sent against it in a most extraordinary manner, and fully maintained the high reputation of the firm and the gradual and certain progress they continue to make even on their acknowledged uniform excellence of both material and manufacture. When Whalley Island is finally prepared and entered upon as the Portsmouth armour-plate and target testing-ground, in the room of the present system of target ships, it will then be worthy of the consideration of the Admiralty, whether it would not be an advantage if all the armour-plates after that time were tested without any backing. The object in firing at armour-plates at all is merely to ascertain the quality of the metal and manufacture, and these objects would be obtained with far greater certainty if the back as well as the front of the plate was open to inspection on the day of trial, and before Capt. Key's report is forwarded to the Admiralty.

Small-arms Manufactory at Birmingham.—At Small Heath, Birmingham, a small-arms manufactory is being built on the plan adopted at the Enfield and London Armoury Company's Works, where every part of the weapon is made in the factory. Being constructed by machinery, all the parts are alike, and can be interchanged.

Blakeley's Gun.—The first of the four rifled guns, weighing 20 tons each, manufactured at the Lowmoor Works, to the order of Captain Blakeley, for the Russian Government, have been tested at the Royal Ordnance butt at Woolwich. The proof charge consisted of 50lb. of powder and a cylinder weighing 600lb., with which was fired two rounds, according to the proof regulations. The result was satisfactory. The fourth of these guns was fired on the 11th ult., with the ordinary proof charge, viz.:—50lb. of powder, a wad, and a 600lb. cylinder. The gun underwent the first round with apparent success, but on making the usual survey and examination it was discovered that the base section at the head of the breech, and into which the "button" appears to be screwed, had given way, and a large rent or split was clearly perceptible.

Experiments at Shoeburyness of some importance took place on the 8th ult. The target tried was called the Bellerophon target, invented by Mr. Reed. The Warrior target weighs about 335lb. to the square foot, and it was thought to be venturing as far as it was safe to go in the new frigates of the *Minotaur* and *Northumberland* class when their bulk was increased to 347lb. per foot. Yet Mr. Reed's target weighs no less than 381lb. per foot, and it is perhaps the heaviest target ever put forward at Shoeburyness which professed to represent the broadside of a seagoing frigate. The size of the target is, in round numbers, 20ft. by 18ft. This is covered in front by two armour-plates, each 20ft. by 4ft. 3in., and no less than 6in. thick. The method of its construction is briefly as follows.— The inner skin of the ship is composed of two thicknesses of wrought iron plates, each three-quarters of an inch thick, with a layer of felt between the two thicknesses, so that here we get no less than 1½in. of iron to start with. On this skin is laid four large angle-irons of great strength, each placed 2ft. apart from the other, so as to form, as it were, four longitudinal troughs 2ft. wide and 9½in. deep, the depth of the angle-irons themselves. In these troughs the teak balks are laid 10in. thick, so that the extra half inch can be cut off to a true surface for the reception of the 6in. armour-plates. Thus, then, there are no less than 7½in. of iron and 9½in. of teak. Each armour-plate is secured by 22 bolts, about 2ft. apart longitudinally, and 2ft. 9in. vertically, those for the upper plate being 2½in. in diameter, and for the lower 2¾in. The bolts securing the wood backing are 1in. diameter, and the ribs supporting the inner skin are on very much the same principle as those used in all iron frigates, only apparently stronger, and placed 2ft. apart. The first rounds fired were merely routine—a 68 solid shot, with a 16lb. charge and 110-pounder Armstrong shortened to a weight of 66½lb., fired with the same charge. Both these struck the upper plate, and made the usual indent of nearly 2in. deep, but effected nothing more than they usually do—that is to say, show the quality of the iron plates against which the guns have to contend. On this occasion the iron was literally perfect, and throughout the rest of the experiments the opinion was universal that better plates had never been tested at Shoeburyness. Even under the heaviest shot, though indented deeply, they showed scarcely any perceptible symptom of buckling out; and though struck on the edge and around the bolt-holes, it was almost impossible to crack them. A salvo of two 68-pounders and two 110-pounder Armstrongs, with shot shortened to 66½lb., was next fired, but of these four guns one missed the target altogether, one touched it so slightly on its upper edge that, as far as damage was concerned, it may also be called a miss; the remaining two struck close together, one on each side of a bolt, so that the bolt itself was squeezed up like putty, and projected slightly outwards, but still held firm. Two shots coming so close were a hard trial for any plate, but it stood it perfectly, without any sign of crack or ragged edges. A cylindrical, round-headed 68lb. shot was next used, but effected nothing, and then the Whitworth 70-pounder muzzle-loading gun was loaded with a steel shell, charged with 2½lb. of powder, and fired with a 12lb. charge. As regarded the target, this effected nothing though its indent at once showed by its severity the immense superiority of steel projectiles against armour-plates over the old gray cast iron shot. The indent made by this shell though only 2lb. heavier than the 68-pounders, was at least 40 per cent. deeper, and its fragments cut into the mass of iron as if it had been wood. Mr. Whitworth's 150-pounder was next tried. In consequence of there being a slight flaw in this gun, Mr. Whitworth reduced its firing charge from 27lb. to 23lb., the shell, of homogenous metal, weighing 151lb., with 5lb. of powder as a bursting charge. Much was expected from this formidable shot, but, unfortunately, it failed—the shell from some cause bursting about 20 yards from the muzzle of the gun, and sending its fragments in all directions. The Armstrong rifled gun was then tried with a spherical cast shot of 151lb., fired with 35lb. of powder. This struck, with the rather high velocity of 1570ft. per second, on the edge of the upper plate, making an indent of 3½in., breaking one bolt, slightly bulging the inner skin of the target, and therefore starting the ribs of the ship itself just enough to be perceptible. Beyond this, however, it effected nothing of importance. A steel spherical shot of the same weight was fired from the same gun with the same charge, and this struck between the slightly parted edges of the upper and lower plates. It completely buried itself, and must have passed through the entire plate, but though two bolts gave way, all the rivets held on; and, although the immense mass was bedded in the substance of the target, it produced scarcely any effect worth speaking of on the inner skin, which, as far as fighting purposes are concerned, remained as good as before it was fired at. A shot from a 7in. muzzle-loading gun of the Ordnance Select Committee was fired with a 120lb. steel shell loaded with 2lb. of powder. This accomplished nothing. A shot from the rifled 300-pounder (a cast iron projectile), fired with 35lb. of powder, did very little, in spite of the weight of the mass hurled against the target. It made an irregular dent of 3¾in. deep, and bent back the upper plate a little more than 2in., making the first real crack in the plate at the point we have mentioned as being where the two shots struck on the bolt-head. From this spot there was now, for the first time, seen a perfect crack, nearly a foot long, and extending quite through the plate, apparently; but this was not all. The last shot fired was from Mr. Whitworth's 150-pounder, loaded with a steel shell and 5lb. of powder. This struck the lower plate, and exploding, buried itself deeply; but though it had evidently penetrated the plates, it had failed to make any perceptible impression on the inside of the target itself.

The Armstrong 600-pounder shunt gun was tested on the 11th ult. at Shoeburyness against the Warrior floating target. The target is an exact counterpart of a section of the *Warrior's* side, and measures 18ft. long by 10ft. in height It is constructed of iron plates of the best homogenous metal 4½in. thick, bolted to a backing of teak 18in. in depth. Behind this come two sets of ⅝in. plates, rivetted to massive ribs of ⊤ iron, the whole being shored up by slanting beams of fir of immense thickness. The target was moored at 1000 yards' distance from the firing points of the 600 and 300-pounder Armstrongs, and wooden targets for ascertaining the correct elevation for this range floated close by, a little clear of the iron one. The first shot was a dummy cast-iron shell weighing 600lb., and was levelled with such unerring aim at the wooden target as to smash it literally to powder. The elevation of the piece in this instance was 2 deg. 5 min., and the charge 70lb. The next shot was a steel shell with a cast-iron head weighing 610lb., and containing no less than 24lb. of powder, which is only four-fifths of its normal charge. Before firing this shot a consultation took place among the artillerists present as to the elevation to be given, it having been discovered that the wooden target demolished by the first shot had been moored at 1020 yards instead of at 1000 as had been originally intended. After some discussion the gun was fired at 2 deg. 10 min. elevation, the shell passing just over the top of the target a little to the right of the central line. The next two shots—live steel shells similar in all respects to No. 2—demonstrated in a most surprising way the wonderful accuracy of the gun in obeying the slightest change in elevation. For shot No. 3 the piece was depressed to 2 deg. 3 min., the shell passing through the exact centre of the top of the target, and carrying away a piece of the wood framing of a semicircular shape. The fourth shot was fired at only 3 min. less elevation, and struck the target as near the centre as possible, making a breach through it, and exploding at the very moment of impact. On boarding the target the havoc made by the ponderous missile was found to have surpassed all expectation. A hole 2ft by 20in. yawned in the 4½in. plate, level with and a few inches on the left of the bull's eye. The teak backing was splintered into fragments from the size of a cocoa nut to the merest fibre, and the ⅝in. plates and one of the ribs were completely torn away like so much paper. In front, below the hole, there lay a huge mass of iron plate, weighing three or four hundredweight. The plate above the one which was pierced was started from its place and bulged outward, nearly the whole of the bolts holding it to the target being broken away. At first it had been intended to try the effects of the 600-pounder upon the Warrior target at 2000 yards, but the first blow at 1000 yards so disabled it as to render a new target necessary. On returning to the firing point the 300-pounder was next tried, four shots being fired, but owing to several causes only one of them took effect. The charges for this gun were found to be a few inches short, the consequence of which was that in three instances the target was missed. At the fourth shot, the charge for which was of the proper size, the shell struck the right top corner of the plate, smashing but not penetrating it. The slight effect taken by this shot was no doubt greatly owing to the target having been slewed round to an angle of nearly 40 degrees with the line of fire by the fourth shell from the 600-pounder.

STEAM SHIPPING.

Innovations in Shipbuilding.—It is stated that the latest and boldest departure from the ordinary form of steamship since the *Great Eastern* is about to be attempted by a wealthy American, who has been for years experimenting upon a new form of vessel, and who has now matured his plans. He will commence the construction of a large ship upon his new system, nearly 300ft. long, at the yard of Mr. Hepworth at Poplar, one of the most striking modifications of which is that the section of the ship is a perfect circle at all points. The hull tapers to the ends. The engines, of about 600-horse power, are being constructed by Messrs. Jackson and Watkins, of London. They have three cylinders and are designed with a view to a saving of weight and space. Steel enters largely into their composition. They will be supplied with all the latest improvements in marine engines. No expense is to be spared to insure success. A second vessel of still larger power and dimensions will shortly be commenced by the same persons.

The Trial Trip of the "Hector" commenced at Portsmouth on the 23rd ult. The *Hector* was laid down in Messrs. Napier's building-yard at Glasgow in March, 1861, and was launched on the 21st of September, 1862. Her principal dimensions are:— Length between perpendiculars, 280ft.; breadth, extreme, 56ft. 3in.; depth from underside of keel to spar-deck, 40ft. Tonnage, builders' measurement, 4123 tons. Launching weight, 3050 tons. Draught of water when launched, 15ft. 8½in. forward, 19ft. 8in. aft. Displacement at load water-line, 6400 tons. Weight of iron used in construction of hull, exclusive of armour, 2588 tons; weight of armour-plates, 873 tons; weight of armoured shield on upperdeck inside stem, 12¾ tons; weight of rudder, 9½ tons; weight of engines, 165 tons; ditto boilers, 220 tons; ditto water in boilers, 90 tons; ditto propeller and shafting, 64½ tons; ditto coal boxes, 37 tons; ditto cupola for hot shot, 7 tons; ditto spare fans, 12 tons; weight of coal railway for transporting coal from coal bunkers to furnaces, 5 tons; weight of auxiliary engines, 9½ tons; ditto spare engine gear, 20 tons; ditto sundries, 23 tons. The propeller is a two-bladed Griffith's, having a varying pitch from 22ft. 6in. to 27ft. 6in. and set now at 26ft. 6in. Space for coals in bunkers, 450 tons, the amount she had in at the commencement of her trial. The engines are 7ft. below the ship's estimated water line, as shown in the drawings, and occupy a space of 27ft. longitudinally. They are on Messrs. Napier's horizontal trunk air-pump principle of 800 horse-power, nominal, and are marvels of engineering work and beauty in casting. The cylinders have a diameter of 82in., and the pistons a stroke of 4ft. The boilers are six in number, three on each side of the stoke-hole; each boiler having four fires, or 24 in all. The *Hector* has no external keel, it being built up internally at about 3ft. in depth, and with the longitudinal girders and floors forms sections of cells which are plated internally and externally, and thus bind together the bottom and frame of the ship. The top sides are built of 10in. angle iron frames, with ⅝in. plates, over which are two layers of teak, the outer layer being 8in. thick, and fixed perpendicularly, the inner layer being 10in. thick and fixed longitudinally, and thus next the ship's inner skin. On this teak cushioning rest the armour-plates, 4½in. in thickness on the broadsides, and tapering round the stem and stern. At the time of the trial the vessel was drawing 24ft. 1¼in. of water forward and 25ft. 4in. aft, the height of her portsills—the lower edge of her gunports—being:—Aft, on the bluff of the quarters, 7ft. 7in.; amidships, 7ft. 2in.; bridle port, 9ft. 7in. The results of the trial were as follows:—

No. of Runs.	Time M. S.	Speed of Ship. Knots.	Steam. Lbs.	Vacuum.	Revolutions of Engines.
1	5 46	10·465	21	26	55
2	4 56	12·162	22	26	57½
3	5 34	10·778	22	26	56
4	5 1	11·160	22½	26	57½
5	5 17	11·356	22	26	57
6	5 21	11·215	22½	26	57

These figures give the first means, in knots as before, 11·313, 11·470, 11·369, 11·658, and

11·285; the second means 11·391, 11·419, 11·513 and 11·471; mean of means, or true speed of the ship, 11·448 knots. The boilers supplied an abundance of steam throughout the trials. The *Royal Oak* it may be said realised 12·528 knots. In turning, or steering, power the ship was as perfect as could he desired, the long straight tiller giving all the command that could be desired over the rudder, and the circles being made as follows:—With the helm hard a starboard and 3½ turns of the wheel, the rudder was got to an angle of 24 deg., the half circle made in 2 min. 45 sec., and the full circle in 5 min. 40 sec., the revolutions of the engines ranging from 57 to 54; with the helm hard a port and 2⅔ turns of the wheel the rudder was got to an angle of 20 deg., the half circle made in 3 min. 13 sec., and the full circle in 6 min. 36 sec., the revolutions of the engines heing from 56 to 52. The ventilation of the ship below during her trial was far from satisfactory. When the ship was going ahead at full speed against the wind the following temperatures were taken below. Temperatures taken during the first run at the measured mile:—On deck, 46 deg.; engine-room, forepart, 75 deg.; middle part, 72 deg.; aft, 76 deg. Stokehole, 1st run, forepart, 70 deg.; middle, 117 deg.; aft, 100 deg.; 6th run, forepart, 76 deg.; middle, 130 deg.; aft, 107 deg.—The *Hector* on the following day completed her official trial, of which the following is the result:—Owing to the speed attained on the previous day being only 11·448 knots, and therefore under the stipulated contract speed of 11·75 knots, it became necessary to give her a second trial at full power, and four runs were accordingly taken at the mile as a commencement of the trial. The mean speed given by these runs was 11·843 knots—a gain of four-tenths of a knot over that exhibited on the previous day, and enough to meet the contract rate of speed. The four runs with half boiler power which followed on the full power runs gave the ship a speed of 9·782 knots. In her half-power rate of speed, however, the *Hector* is also behind the *Royal Oak*, the latter ship having realised with half-power 10·140 knots. The speed trials having heen concluded, the ship was next tested in making circles with half hoiler power with the following results:—Helm hard a starboard, angle of rudder, 28½ deg., turns of wheel, 4, half circle made in 3 min. 3 sec.; full circle made in 6 min. 28 sec.; revolutions of engines, 44 to 38; helm hard a port, angle of rudder, 22½ deg., turns of wheel 3, half circle made in 3 min. 39 sec.; full ditto, 1 min. 34 sec.; and revolutions of engines, 46 to 44. The starting gear of the engines was severely tested on the previous day, and worked in a most satisfactory manner. The engines were stopped dead from the time of giving the order in ten seconds; started ahead again in ten seconds, and started astern in five seconds. Throughout the two days' trials the engines of the *Hector* did their work in a most satisfactory manner.

The Kinshau new steamer, belonging to Messrs. Augustine and Co., underwent, at Hong Kong, her trial trip on the 30th October last. The *Kinshau* steamed up the Canton River for a distance of 28 miles, which was performed in two hours under 25lb. steam, her full power being 30lbs. The vessel arrived in March last year, in pieces, from New York, and was built in Messrs. T. Hunt and Co's establishment at Whampoa. The following are her dimensions:—Length between stem and stern, 230ft.; hreadth of beam, 35ft.; depth of hold, 10ft.; diameter of cylinder, 56in.; 10ft. stroke; dimensions of hoilers, 28ft. hy 9ft. 6in.; diameter of wheel, 26ft. with 9ft. face; tonnage, carpenter measurement, 850.

The "Tamar," iron screw troop ship 2812 tons, and 500 horse-power, steamed to the measured mile off Malpin Sands to undergo an official trial of speed on the 1st ult. Six runs were made with the full boiler-power at the measured mile, giving an average speed of 10·778 knots an hour; pressure of steam, 25lb.; vacuum, 24½lb.; and revolution of engines, 52 per minute. At half hoiler power the vessel made two runs at a speed of 9·290 knots; with 46 revolutions of engines. The circle was turned at full speed, with helm 24 degs. to port in 9m. 2s., with 50 revolutions of engines, the diameter of the circle being 1·286 yards. The vessel is fitted with horizontal direct acting engines which worked in an excellent manner, there being an entire absence of priming or hot bearings and plenty of steam. The propeller is Griffith's patent, with a pitch variahle from 25 to 30ft. On the trial the pitch was 27ft. 6in., and the diameter 18ft. The draught of water, hoth forward and aft, was 22ft. 4in. The wind was from the S.S.W., with a force of from 5 to 6, and the sea was rough. The screw was lifted from its place and replaced with rapidity and precision; and the trial, both as regards vessel and machinery, gave the greatest satisfaction. The *Tamar's* engines were manufactured by Messrs. Ravenhill, Salkeld, and Co.

The "Winnebago," United States iron-clad steamer, left St. Louis on the 20th Oct., on a trial trip. She was operated on 72 consecutive hours, the engines making 67 revolutions per minute, and the propellers 112 revolutions. With this speed of screw, the vessel sailed 9 miles an hour in smooth water. The *Winnebago* is the first of four sister propellers launched, and considerable anxiety was therefore manifested in the result. It is gratifying to know that everything worked satisfactorily. The vessel is of iron, 220ft. long, 56ft. wide, and 7ft. deep. She has two fore-and-aft hulkheads and six thwart-ship hulkheads, all water-tight. She has two turrets, one Ericsson's and the other Ead's patent. The latter turret differs from Ericsson's, among other things, in having a portion of the shell entered down to, and the whole weight of the turret resting on spheres at the bottom of the vessel. The guns are placed on a huge platform, loaded in the hold, and raised in the turret hy steam power. They also run out by steam; the recoil is received on steam cylinders, and the whole apparatus, guns and all, is operated by one man (an engineer), no other person being needed in the turret. The loading is accomplished by loaders helow the turret, in the hold.

Steam Shipbuilding on the Clyde.—Messrs. Aitken and Mansel, of Whiteinch, have launched a screw of 860 tons, builder's measurement, named the *Busheer*, huilt for the British India Steam Navigation Company. The *Busheer*, which will he fitted with patent reefing gear, a steam windlass, and other recent improvements, is heing supplied with direct acting engines and hoilers of 120-horse power, by Messrs. J. Aitken and Co., Cranston-hill. Messrs. Aitken and Mansel have at present in course of construction two paddles of 600 tons and 630 tons respectively. A paddle of 600 tons, built and engined hy Messrs. W. Simens and Co., has been launched from the London Works, Renfrew. She is named the *Julia*, and is fitted with oscillating engines, feathering floats, &c. A screw, named the *Coquette*, built hy Messrs. Henderson, Coulhurn, and Co., of Renfrew, and fitted on their new principle, with double propellers, has made the run out from Liverpool to Bermuda in twelve days. Messrs. Henderson, Coulhurn, and Co., have a duplicate of the *Coquette* in course of construction, which they expect will attain a speed of 16 knots per hour. A tug named the *Bulldog*, huilt hy Messrs. Blackwood and Gordon, of Port Glasgow, for towing purposes on the Ganges, has made a successful run out. A satisfactory trial trip has heen made hy the *Wellington*, a screw, built and engined hy Messrs. Blackwood and Gordon, of Port Glasgow, for the New Zealand Steam Navigation Company (limited). The steamer, which has accommodation for 100 passengers, is of the following dimensions:—Length of keel and fore-rake, 182ft.; hreadth of heam, 24ft. 6in.; depth of hold, 14ft.; hurden, 527 tons. She is fitted with horse-stalls and every requisite for the New Zealand trade, and is propelled hy a pair of direct-acting inverted condensing engines of 80-horse power. The diameter of the cylinders is 34in., and the length of stroke 27in. Her consumption of coal when the full power of the engines is exerted is about 10 cwt. per hour. In running the distance between the Cloch aud Cumhrae lights, the *Wellington* had the tide against her, hut she averaged, nevertheless, an uniform speed of 12·615 knots or 14·532 miles per hour. The New Dumharton Steamboat Company has ordered two paddles, to ply on the Clyde, and which are to he built hy the Clyde Shiphuilding Company, Ladyburn Works, Glasgow, and her engines will be supplied by Messrs. Rankin and Blackmore, of Greenock. Messrs. M'Nab and Co., of Greenock, have launched a screw named the *Rhoda*, 352 tons hurden, and fitted with direct-acting engines of 50-horse power.

Iron Shipbuilding in South Wales.—Messrs. Scott Russell and Co. have commenced operations with the view of constructing an iron shipbuilding dry dock at Cardiff, and Messrs. Batchelor, of the same place, will lay down an iron vessel in a few weeks. Messrs. Hill and Son, who were the first to huild an iron vessel at Cardiff, have commenced another of 630 tons register. The Newport Wood and Iron Shipbuilding Company and the Llanelly Company have also commenced operations, and the former have purchased the dry dock of Messrs. Willmett aud Co., Newport. In consequence of these extensions a large demand will necessarily arise for armour and ship plates, and the Rhymney Iron Company, in order to meet the demand, have already commenced the erection of a plate mill.

LAUNCHES.

The Launch of the "Minotaur" from the yard of the Thames Ironworks took place on the 12th ult. The *Minotaur* is the first launched of the new class of *Warriors*. The *Warrior* class are 4½in. of iron and 18in. of teak; the *Minotaur* and *Northumberland* class are 5½in. of iron and 9in. of teak. The reduction of the timber and the increase of iron were at the time rather hastily made, and since then it has been shown that that the thickness of the hacking to the armour-plates is to the full as important as the thickness of the armour-plates themselves. In size aud estimated speed, however, the new class are an improvement on the old. They are 20ft. longer than the *Warrior*, and will have engines of 100 nominal horse-power greater. There are at present, exclusive of the wooden ironclads, three pairs of iron-plated ships afloat. The *Warrior* and *Black Prince* are each of 6176 tons, with engines of 1250 horse-power; the *Defence* and *Resistance* are each of 3720 tons and 600 horse-power; the *Hector* and the *Valiant* are of 4063 tons and 800 horse-power; of the largest ships there is the *Minotaur*, 6812 tons and 1350 horse power, and the two sister ships now in course of building—the *Agincourt* and the *Northumberland*—the former at Birkenhead and the latter at Millwall. The six ships first mentioned are only partially protected by armour-plates; two of them the *Hector* aud the *Valiant*, have armour carried right fore and aft, covering all the guns; hut for about 60ft. at each end they are unprotected on the water-line. The three last-mentioned are protected from stem to stern on the battery as well as on the load-line.

Steamship Building at Waterford.—The *Iowa* screw steamship was launched on the 28th November last, from the huilding-yard of the Neptune Iron Works, at Waterford; her dimensions are—length, 330 ft.; breadth, 35ft.; depth, 27ft.; hurthen over, 3500 tons. The *Iowa* is the property of the firm of Messrs. Malcolmson, Brothers, Waterford, and Mark Lane, London, and is intended for the Havre and New York line. She is fitted with all the modern, scientific, and mechanical appliances, superheaters, waterheaters, condensers, steam winches and cranes, Horns' patent valves, and steering apparatus; also Suffields' engine-room telegraph, and in her construction no expense has been spared to render her complete for her station. This splendid ship was designed by Mr. J. Horn, the manager of the works, and is the twentieth steamship he has added to their extensive fleet.

Launch of the "John David."—The iron screw steamer *John David*, the first of six steam vessels to be constructed in this country for the firm of David Verbist and Co., Antwerp, was launched on the 10th ult., from the building-yard of Messrs. Rennie, Greenwich. The *John David* and the others that are to follow, are intended for the Black Sea and Sea of Azov trades. The dimensions are 240ft. between perpendiculars 30½ft. beam, 18½ft. depth of hold; tonnage 1100. The engines, finished with all the most recent improvements, will work up to 500 effective horse-power.

The Launch of the "Achilles" was, after some difficulty, achieved on the 24th ult. The *Achilles* is the first of the large iron vessels, which has been built at a Royal dockyard—the whole of the squadron of iron-clads now afloat, including the *Minotaur*, *Warrior*, *Black Prince*, *Defence*, &c., having been built for the Government at private establishments. The first armour-plate was bolted to the sides of the *Achilles* on the 5th of February last, and since then she has received upwards of 1200 tons of armour-plating, the *Achilles* heing the first iron vessel launched with the whole of her armour-plating complete from stem to stern. The dimensions of the *Achilles* are slightly in excess of the *Warrior*, while her length is only a few feet below that of the *Minotaur*, recently launched from the yard of the Thames Ironwork Company. She is 385ft. 9in. in length, 58ft. 3¼in. in hreadth of beam, and her burden is 6,080 tons. Instead of being covered with armour-plating only on her hroadsides, as is the case with the *Warrior*, *Black Prince*, and *Defence*, the *Achilles* carries her shield-plates right round the ship, from stem to stern, the total number of armour-plates bolted to her sides heing 336. Notwithstanding the additional 500 tons of plating, she carries, as compared with the *Warrior*, she has a light, huoyant appearance in the water, and, although her displacement is calculated at nearly 10,000 tons, her launching draught was only 20ft. and a few inches. The whole of her broadside plates are 4½in. in thickness, and are of rolled iron, from the Parkgate Works, Yorkshire. Towards the stem and stern the plates have a tapering form, until a *minimum* thickness of 2½in. is obtained. The plates under the counter and buttock are of this thickness, and were manufactured by Messrs. John Brown, and Co., Atlas Works, Sheffield. For a length of 200ft. on each broadside the armour-plates are carried up to the floor of the fighting or weather deck. An armour-plated bulkhead, one of which is placed fore and aft, runs across the gun deck, and consequently encloses this portion of the vessel, in which nearly the whole of the guns are placed, as a shot-proof battery, the armour-hulkhead preventing the fire from an enemy's guns raking the vessel fore and aft. On each side, fore and aft of the armour-hulkheads, the armour-plates are only required to he carried as high as the floor of the main deck. The *Achilles* is pierced to carry 46 guns on her main deck, with four Armstrong pivots fore and aft on her weather deck, hut it is probable that her armament will not exceed, in the aggregate, 34 guns. Her port-sills, which are enclosed with gun-metal lids, are very small, their dimensions heing 3ft. 8in. hy 1ft. 11in. On the inside they are emhrasured, which will enahle the guns to have a play of at least 90 deg. in each direction. At her load draught of water her port-sills will be 9ft. 6in. above the water. The *Achilles* is constructed with two horizontal keels overlapping each other, with a vertical keel 3ft. 6in. in depth, and a hox keelson, 2ft. 6in. deep above the water-tight bottom. This form of construction, while it lessens the chance of accidents to her bottom, will also enable water-hallast to be added so as to alter the vessel to any trim, should that hereafter he necessary. The *Achilles* is constructed on a two-feet flatter section than the *Warrior*, which enahles her engines and boilers to he placed lower in the vessel. This will very materially lessen any attempts to to roll, which will he still further prevented hy two hilge keels, 12ft. apart, running the whole length of her broadsides, on each side of the hull. In solidity of parts and strength of materials the *Achilles* is helieved to surpass every iron ship yet constructed, no expense either of time, lahour, or outlay having been spared hy the Admiralty to render her in all respects perfect. For a length of 220ft., her sides are 3ft. 1in. in thickness, which is made up of 14in. of iron rib-framing, the iron skin plates 3-quarters of an inch in thickness at the stoutest part, 18in. of teak-timher planking, and finally the 4½in. armour-plates. In the remaining portions of the stem and stern the thickness of the sides gradually lessens, until a *minimum* thickness of 1ft. 11in. of iron and teak is obtained. The large iron ribs are each 3ft. 8in. apart; and between these are numerous smaller frames, the whole of which are riveted to the vertical keel. Binding the whole together in one solid mass of iron work are 12 longitudinals, six on each side, running the entire length of the vessel. Additional strength is also obtained by means of the iron deck beams, which carry the iron deck plates. On the main deck the beams are 1ft. 4in. in thickness, on the lower

deck 1ft. 3in., and on the upper deck 12½in. In order to move such an enormous mass through the water at a speed of at least 14 knots, equal to 16 statute miles per hour, the *Achilles* is to be supplied with engines of 1,250 (nominal) horse-power; but capable of being worked up to double that force. Her engines are being fitted on board by Messrs. John Penn and Sons. Her screw is four-bladed, and in consequence of there being no screw-well to the *Achilles*, it will not be possible to lift the propeller during the time the vessel is not under steam.

TELEGRAPHIC ENGINEERING.

THE INDIAN TELEGRAPH.—Colonel Stewart, Sir Charles Bright, Captain Stewart, Mr. J. C. Laws, and Mr. F. C. Webb have arrived at Malta in the steamship *Valetta*, from Marseilles, and passed on in the same vessel for Alexandria, for the purpose of superintending the laying of the electric cable in the Persian Gulf. The five ships forming the squadron for conveying the cable to its destination will rendezvous at Bombay, whence they will proceed to lay their respective sections. The submergence of the cable is to commence as soon as possible after their arrival. The staff of electricians, telegraphists, &c., have been sent in the various cable ships, all of which have left England. The submarine line will be laid in four sections between Bussorah, at the head of the Persian Gulf, and Kurrachee, having intermediate stations at Bushire, Khasab, and Gwadel. The land line from Bussorah to Bagdad, and thence through Asia Minor, is being proceeded with with all possible despatch.

TYPO-TELEGRAPHY.—Some interesting experiments have been made in France at the Ministry of the Interior in the telegraph offices. The system of typo-telegraphy, invented by Chevalier Bonelli, was tried on the line between Paris and Boulogne-sur-Mer. The results were very satisfactory. In spite of the bad state of the line and wet weather, the impression of the despatches left nothing to desire, either in regard to the good formation of the letters or the rapidity of transmission. By this new system, three hundred despatches per hour may be printed in duplicate, and at very great distances. There is little doubt that it will be adopted all over the Continent.

RAILWAYS.

THE CHARING-CROSS RAILWAY.—Captain Tyler, the Government inspector, in company with Mr. Hawkshaw, has renewed his inquiry into the condition of this line, and tested the numerous iron road-bridges that carry it from the Charing-cross Bridge to the London Bridge terminus. The structures, it is said, were severally tested with weights equivalent to a ton per foot on each line of rails, the general average deflection being only half-an-inch on the centres, and a quarter-of-an-inch on the cross girders. The iron plate girder-bridge at the London Bridge end is the largest structure of its kind, extending over a total span of 186ft., and weighing upwards of 300 tons. The bow and string bridge over Southwark-street has a span of 132ft. in the clear.

THE FESTINIOG RAILWAY, in North Wales, a line 14 miles long, with an uniform inclination of 1 in 80, and a gauge of only 2ft., was opened recently for traffic with locomotive power. The engines, which only weigh 5 tons, are the smallest ever made for railway traffic. They are beautiful, low-built, compact four-wheeled coupled tank engines, with cylinders 8in. in diameter, and wheels 2ft. in diameter. At the opening of the Festiniog Railway each engine conveyed a train of about 30 tons weight up the line and round curves of 130ft. radius at a speed of 13 miles per hour with perfect ease.

CLARK'S SAFETY RAILWAY BRAKE.—An experimental trial of this brake has been made on the North British Railway, of which the following is the result. The train consisted of five loaded carriages. The engine was one of the high-speed mail class, with 6ft. driving wheels. The first stoppage was made on the gradient near St. Margaret's, of 1 in 75. With a speed of above 40 miles per hour, the train was stopped in about 300 yards; and on the level, at a speed of 30 miles an hour, the train was stopped in about 100 yards. Other trials were made equally good. The brake is applied by one man on the tender instantaneously, by simply screwing friction-wheels against the running-wheels of the tender. The brakes, which are fitted to the carriages, are compressed uniformly, so that no concussion is felt in these short-ranges, which are about an eighth part of the distance a train can be stopped in by the present brake power.

RAILWAY CLAUSES.—An Act was passed in the last session to consolidate certain provisions usually inserted in railway Acts. It will take effect in the next session, when numerous railway Bills will be brought before the House of Commons. The Act is divided into parts relating to the construction of railways, the extension of time for the purchase of land and construction of works, the working agreements, steam-vessels, and the amalgamation of railways. The Act provides that, for the greater convenience and safety of the public, companies must erect and maintain lodges at points of crossing, and the speed of travelling at such places is to be regulated by the Board of Trade. For neglect a penalty of £20 is to be incurred, and a penalty of £10 for every day during which the offence is continued. The effect of the statute will be to shorten railway Acts.

INDIAN RAILWAYS.—On November 11th took place the opening of the first line of the Indian Branch Railway Company, from Nulhatee to Jeeagunge. Nulhatee is a station on the East Indian Railway, 145½ miles from Calcutta, and 27 miles distant from the Bhagurutee river, which, with two others, leaves the Ganges to join the Hooghly, on which Calcutta stands. Jeeagunge is on that river, a few miles from the old Mussulman capital of Bengal Moorshedabad, near which is our civil station of Berhampore. All around is a rich silk and indigo country, as thickly peopled as England, and fruitful in all tropical products. Some years ago the Bengal Government began to lay down a road along these 27 miles to feed the railway, and Mr. J. E. Wilson, who had made a most difficult section of the East Indian line, offered to put down a light railway on this road for not more than £3000 a mile. The road cost Government £1000 a mile, and this they gave to the branch railway company established by Mr. Wilson as a subvention or substitute for the now abandoned guarantee system. The new line, at right angles to the East Indian, is a four-foot gauge, the rails are half the ordinary weight and price, and they lie on sleepers, which are simply thin bars of the best teak wood, with two inches of teak at either end, each sleeper costing 2s. or a fifth of the ordinary price. The carriages are like American cars, with a door at each end and none at the sides; and for third-class passengers, who will squat on the floor as Asiatics do, there are two tiers above and below, the upper reached by a movable ladder. Each carriage carries 200 passengers, and stands on three pairs of wheels, the pair at either end being movable, so as to suit curves. The carriage is 50ft. long, and the difference in its weight compared with the ordinary heavy vehicles is that between 6 tons and 30 tons. The engine is five tons less in weight than usual. Another new feature is this—that the carriages rest on springs attached to an iron rod which runs under each, and each rod is so fastened to its neighbour that the train forms an articulated whole, and bad jolting is impossible. Although the railway is constructed for a *minimum* and ordinary speed of 12 miles an hour, the special train went easily to Bokhara, the half way station, at the rate of 30 miles an hour. The Lieut.-Governor, in proposing success to the Company and Mr. Wilson, declared his great satisfaction with the success of the experiment and his conviction of the important results it would have in the country. He stated that while the East Indian line had cost £19,000 a mile, this had cost only £1900, exclusive of the road. He has asked the company to continue this line across the Ganges by Dinagepore, direct north to Darjeeling. Some months ago Lord Elgin conceded to the company all the new lines to be made in Rohilcund and Oudh—900 miles in all, but their gauge will be the regular Indian one of 5½ft., and the engines will be more powerful, while the rails are to be tipped with steel. Within the next five years Mr. Wilson has contracted to make a main line from the Ganges opposite Buscar to Seharunpore near Merut, on the Delhi and Lahore line. From this branches will go to Benares, through Juanpore to Fyzabad, to Lucknow and Cawnpore, to Nynee Tal in the hills, and to Allyghur, the present extreme terminus of the East Indian line.

GREAT AMERICAN LOCOMOTIVE.—An American railway paper gives the following account of this locomotive:—"The giant anthracite coal-burning locomotive pusher, lately designed and built by Millholand, for the Philadelphia and Reading Railway is to be used for pushing heavy coal trains between the Schuylkill river and the coal piers at Port Richmond, where there is a grade of about 34ft. to the mile for one and three-fifths miles. The following is the description of the dimensions of this monster pusher:—Number of drivers, 12; diameter of drivers, 43in.; between centre of axles, 3ft. 11in.; wheel base, 19ft. 7in.; diameter of cylinder, 20in.; stroke of piston, 26in.; length of main rod, 11ft. 4in.; length of steam ports, 18⅝in.; width of steam ports, 1⅝in.; width of exhaust ports, 3¼in.; lap of valve ⅛in.; diameter of boiler, 48in.; number of tubes, 174; length of tubes, 13ft. 6in.; diameter of tubes, 2in.; inside length of fire-box, 9ft.; inside width of fire-box, 42in.; depth of combustion chamber, 25in.; total heating surface, 1428 square feet; grate area, 31½ square feet; length of engine over all, 36ft.; width of engine over all, 8ft. 6in.; height from rail to top of stack, 14ft.; weight of engine, 100,320 pounds. The water tanks, three in number, are placed one on each side of fire-box beneath the foot-board, and one over top of fire-box with an aggregate capacity for 1224 gallons. The firing, when necessary, is done at the ends of trips, no coal being carried excepting that in the fire-box. Two Giffard injectors, Nos. 9 and 10, are provided for feeding the boiler. The exhaust nozzle can be varied from 11 to 23 square inches in area. The great bars are hollow tubes, having a circulation of water through them, James Millholland's patent. Length of grade upon which the engine operates 9000ft. Height per mile 34ft.

NEW RAILWAY BRAKE.—*Galignani* states that some interesting experiments have been made on the Entre-Sambre-et-Meuse Railway, in Belgium, between the stations of Frayre and Walcourt, to test the efficacy of a new brake, which is the more interesting as it is the invention of a lady, Mdlle. Micas. The principle of the invention consists in the sudden application of a sort of wooden skate, or wedge, to the wheel, whereby it is raised a millimetre or two. From that moment the rapidity of the train is checked, and a few seconds are gained, which, as may be imagined, are of immense value in case of danger. The action upon the brake is transmitted by a single man pressing upon a rod connected with the wedge, and without the aid of a screw. M. Gohert, the engineer of the Government railways in Belgium, directed the experiments, and many other Belgian and foreign civil engineers were present. A train, weighing 195,000 kilogrammes, was allowed to descend a gradient of 14 millimetres per metre by its own weight, and without the aid of an engine. Two brakes being used, the train was stopped in a space of 300 metres, while going at a speed of 36 kilometres (22½ miles). In another experiment a train was drawn by a 16in. engine, with four coupled wheels, along a level railway, and at a full speed of 55 kilometres (34 miles) per hour. A single brake stopped the train within the space of 400 metres. With two brakes the stoppage was obtained within the space of 175 metres; and at a speed of 60 kilometres (38 miles) per hour, the stoppage was effected within the space of 165 metres only; results far superior to those obtained with the common brakes now in use.

NEW RAILWAY LAMP.—The trial of a newly-invented lamp for lighting railway platforms, goods stations, &c., recently took place at the Devonshire-street depôt of the Great Eastern Railway. The yard of the depôt in question is about a quarter of a mile in length, and although four of the new lamps were erected, only two were used. The light from them was found amply sufficient to enable the workmen in every part of the yard to dispense with the ordinary hand-lamp hitherto in use. In fact, such was the illuminating power of the light that small print could be read with facility at a distance of 45 yards, and the scientific men who witnessed the effect expressed their entire satisfaction with the result of the trial. The lamps are constructed and fixed upon the principle invented by Dr. Brown, late of the Royal Navy, and are already in general use on the Great Eastern Railway.

ATLANTIC TO THE PACIFIC.—In a prize essay on British Columbia which has recently been published in that colony, the writer, the Rev. R. C. L. Brown, discusses the difficulties of constructing a railway across the North American continent in British territory, and maintains that they have been greatly exaggerated. He says:—"There is steam communication to the head of Lake Superior; thence to the Red River Settlement a road could be made without much difficulty. From the Red River to Edmonton the way lies up the valley of the great Saskatchewan River, navigable for 700 miles. This is described as a splendid and extensive valley, capable of supporting a large agricultural population. At Edmonton the difficulties begin. Thence to Jaspar House in the Rocky Mountains, 400 miles, the country is swampy and bad. There is a coal-field here, and the seams appear on the surface, at some places on fire. Here the party from which this information is obtained (the party of Canadians who entered British Columbia by this route last autumn) built their nightly camp fires of coal. The gorge through which this road enters British Columbia is the New Caledonia or Jasper Pass. It is described as a natural roadway through the mountains, which rise on either side like a wall, to the height of many thousand feet. From Jasper House to Tête Jaune Cache, at the head of the Fraser, the country around is rugged and mountainous; yet there is a valley through which a road or railway could be carried. From Tête Jaune Cache the road would probably take a direct course for Cariboo, by one of three valleys, as yet unexplored, which appear to connect the latter with the head waters of the Fraser. From Cariboo the line would be taken to the mouth of the Quesnelle River, where it would join the great highways from the Lower Fraser, and (should such be ultimately constructed) from Bentinck Arm or any other seaport on the north-west coast. The whole distance between the heads of navigation—namely, from Lake Superior to Bentinck Arm, by this line is about 2200 miles. It is preferable to the route by St. Paul's, Minnesota, because the whole course lies through British territory; and the Jasper Pass road is more free from Indian molestation than the more southerly passes."

RAILWAY ACCIDENTS.

RAILWAY COLLISION.—On the evening of the 28th November last an accident occurred on the Midland Railway, at Beeston (near Nottingham), during the prevalence of a fog. It appears that a passenger train from Derby due in Nottingham about 7.50 p.m., and a goods train from Nottingham, ran into each other near Beeston Station. Neither train was going at great speed, and to this fact it may be attributed that no lives were lost. Both engines are much damaged, and one or two carriages smashed.

ACCIDENT ON THE GREAT NORTHERN.—On the 3rd ult., an accident occurred on the Great Northern Railway. At a place called New England, about two or three miles from Peterborough, the company have extensive works. From the sheds here the engines are often started on their journeys, and the intricacy of the metals is such that, in spite of every precaution, accidents are of frequent occurrence. About half-past four o'clock a.m. a pilot passenger engine started from New England towards Peterborough, with a driver, a fireman, and the guard of a passenger train. Immediately afterwards it was followed on the same line by a powerful goods engine. It was very dark, and it was raining. It was impossible to look out, and the goods engine ran into the pilot engine. The shock disconnected the pilot engine from its tender, and all three men fell off. The guard was killed instantaneously, and the driver and fireman seriously injured. The pilot engin

having neither driver nor fireman, dashed into the station at the rate of nearly 40 miles an hour, and coming up with a goods train, smashed the break van to atoms.

Accident on the Great Eastern.—On the morning of the 16th ult. between 3 and 4 o'clock, a heavy fish train came to a stand on the up line of the Great Eastern Railway between Brentwood and Romford. As the 4 o'clock morning mail was nearly due, and it was fonnd impossible to remove the fish train, the officials resolved to work the mail upon the down line as far as Romford, where it was to have gone on the up line again to London. The mail train, consisting of an engine, three or four carriages, and break van, came up at its appointed time. One set of points were shifted, but a second set it is believed were neglected, and instead of the mail going as intended on the down line, it went across the rails, along a bank siding composed of a wooden frame filled in with earth and stones. The engine was overturned into an adjoining field, dragging the carriages after it. The stoker was killed on the spot, and the driver badly hurt. It is unusual for many passengers to travel by this train, and there were only two in it at the time of the accident, neither of whom were severely hurt.

Collision on the Scottish Central Railway.—On the evening of the 18th ult., about 6 o'clock, a collision took place between a ballast train and a goods train at Dunning, on the Scottish Central Railway, about nine miles from Perth. The ballast train, consisting of an engine with trucks attached, and at the end of these a third class carriage conveying plate layers and other railway labourers returning homewards, had, stopped at the station, on the down line. It had scarcely done so, when a goods train was seen approaching the station on the same line at full speed. Being on an incline, the driver could not, on coming in view of the ballast train, arrest the progress of his engine and train, and accordingly it dashed into the third-class carriage, which it instantly shattered, besides greatly damaging the trucks. Two men were killed on the spot, and three or four other labourers were very seriously injured. The men on the engine of the goods train escaped.

Accidents on the Great Northern Railway. — About half-past 10 on the evening of the 17th ult. a coal train was travelling on the up line of the Great Northern Railway. When two miles from Corby the drawing-up bar between two of the trucks broke, causing the train to part. The pin buried itself in a slanting position in a sleeper, and the last part of the train, running upon it, was thrown off on the down line. The lines were in a short time cleared, and the traffic resumed about 7 o'clock next morning. This had scarcely been effected, however, when another accident more serious than the first occurred. The traffic was being worked on a single line between Bytham and Corby. Six trains had successfully passed, and a cattle train was waiting its turn, when a coal train, running past all the signals, dashed into it. The shock was so severe that many of the cattle were killed and others jerked out of the trucks. A drover was injured, and the driver of the coal train was also hurt. The damage to the trucks, &c., was very great.

Accident on the North-Eastern Railway.—On the 15th ult., at 7.15 a.m., the Government train to Hull and Leeds, consisting of an engine, two guards' vans, and eight carriages, left York, and proceeded, without interruption, to Capmanthorpe. It left that station, and proceeded on its journey at an easy rate, but when opposite the fifth mile past from York, the guard in the first van was alarmed by feeling a sudden jerk, which shook him violently. He was about to look out of the van window, when another shock threw him back with considerable force into the van. As soon as he recovered he looked out, and saw that some six or eight carriages were loose from the first portion of the train, and were thrown down an embankment some 10ft. or 15ft. high. The engine was detached from the train, and at the next station transferred to the other line, returning to York at the greatest speed to spread the alarm. In a short time the company's engineer was on the spot, accompanied by a body of workmen. On arriving at the scene of the accident it was found that the whole of the passengers, some 50 in number, had scrambled out of the carriages. Though the unfortunate passengers had been turned over and over down an embankment in railway carriages proceeding at the rate of 20 miles an hour, not one was killed, nor was there anyone seriously injured.

Collision on the London and North-Western Line.—The train from Northampton, due at Stamford at 6.40 p.m., met with an accident on the 16th ult. At Holt, near Medbourne, there is a siding, on which stood a number of trucks heavily laden with stone. It appears that from some cause the points at Holt were left open, and the consequence was that when the passenger train came up at 6.15, it was turned from the mainline, and upon the siding. The train was proceeding at average speed, and came with considerable force in collision with the stone waggons. The engine and several of the carriages were much damaged, but there was no loss of life, though many of the passengers were more or less hurt. The guard states that just before the shock was felt he thought something was wrong, from the rattling of the train over the points, and he was in the act of applying the break when the collision took place.

BOILER EXPLOSIONS.

Manchester Association for the Prevention of Steam Boiler Explosions:—At the monthly meeting, held November 24th, 1863, the chief engineer, presented his monthly report, of which the following is an abstract:—"During the past month there have been examined 238 engines and 381 boilers. Of the latter, 17 have been examined specially, 9 internally, 55 thoroughly, and 300 externally, in addition to which 1 of these boilers has been tested by hydraulic pressure. The following defects have been found in the boilers examined:—Fracture, 10 (1 dangerous); corrosion, 25 (5 dangerous); safety valves out of order, 1; water gauges ditto, 30 (3 dangerous); pressure gauges ditto, 5; feed apparatus ditto, 2; blow-out apparatus ditto, 15 (1 dangerous); fusile plugs, ditto, 3; furnaces out of shape, 12 (3 dangerous); over pressure, 3; (1 dangerous). Total, 106 (14 dangerous). Boilers without glass water gauges, 3; without pressure gauges, 45; without blow-out apparatus, 48; without back pressure valves, 72. An illustration has lately been met with of the importance of removing portions of midfeather walls, in order to give an opportunity of examining the plates. On this being done at the instance of this Association, in the case of a boiler lately put under its care, the bottom, although presumed, by its owner and engineer to be perfectly sound, was found to be nearly eaten through by corrosion, and on the very point of rupture. No. 31 explosion. It has been ascertained that the boiler was of plain Cornish construction, having a single flue parallel throughout; its length being 25ft. 3in., its diameter in the shell, 5ft. 7in., and in the flue, 3ft. 5in., while the thickness of the plates was three-eighths of an inch, and the pressure to which the safety valves were loaded, 40lb. Such a flue, on account of its large diameter, was unsafe from the day on which the boiler was made, though it might easily have been made secure by adopting any of the well-known plans of strengthening flues, among which may be mentioned, hoops, whether of T iron, angle iron, or bridge-rail section, as well as flanged seams. No. 38 explosion. This boiler was of plain cylindrical egg-ended shape, externally-fired, and connected by its steam-pipe to two others of different construction; all three collectively working an engine and forge hammer in the rolling mill. The ordinary working pressure of the boiler was 40lb., its length, 35ft., and its diameter, 6ft. 5in., while the plates were of the most unusual and unnecessary thickness, of from nine-sixteenths to five-sights of an inch. It is more difficult to make good work in a boiler with such thick plates, and it is reported that the joints in the present instance were imperfectly closed—that there bad been unfair use of the drift, than which few things are more prejudicial to the strength of the boiler—that but few of the rivets were properly laid up, while, in addition, the overlap of the plates at the seams of rivets was unusually wide, and, in short, that the work was altogether most clumsy and inferior. Added to this, the boiler had been repaired over the fire more than once, with plates one-eighth of an inch thinner than the rest, while longitudinal seams of rivets, six feet long, were allowed to fall within the furnace, their original length having been increased by the repairs. The explosion was considered to be due to excessive pressure of steam, a pressure greater than that at which the boiler was ordinarily worked, and which it was thought might have arisen in the following way:—The explosion occurred shortly before four o'clock in the afternoon, the boiler having been cleaned out the same morning, while the other two to which it was connected were working alongside meantime. In order to clean this boiler out while the others connected to it had their steam up, it was necessary that the junction valve should be closed, and if this valve had not been re-opened, as it ought to have been, as soon as the steam was up—then in the event of the only safety-valve with which this boiler was fitted, either sticking fast in its seat, or being tampered with—the steam would be bottled up, and the pressure continue to rise, without giving any sign until actual explosion resulted, since there was no steam gauge upon the boiler. One or the other of these two conditions it was concluded had occurred, viz.:—Either that the safety-valve had stuck fast in its seat, or had been intentionally tampered with, at the same time that the boiler was isolated from the other two by the junction valve being shut down. No. 39 explosion. This boiler, which was fifteen years old, was of plain double-flued construction, internally-fired, and of the class termed Lancashire, its length being 32ft., its diameter, 8ft. in the shell, and 3ft. in the flues. It worked alongside of another boiler very similar to itself, and to which it was connected. The boiler had a rent at the bottom of the shell, immediately over the mid-feather wall on which it had rested. This rent, which may be termed the primary one, extended longitudinally for about two rings of plates, and then assumed a transverse direction, running completely round the boiler and severing an entire, though rather irregularly-shaped, belt from the shell. The front end plate was separated from the other part of the boiler, while the furnace tubes, which appeared perfectly sound, remained attached to the rest of the shell, which had been thrown out of its original seat and turned bottom upwards. The longitudinal stays for stiffening the end plates, though massive, were curled up into a scroll, and the transverse ones, which should never be introduced in a cylindrical boiler, proved, as might have been expected, of no assistance in strengthening the shell. As to the cause of the explosion there can be no question; there was no evidence of shortness of water, the furnace crowns being uninjured, but on examining the edges of the plates at the primary rent, which had occurred over the mid-feather wall, their thickness was found to have been so reduced by external corrosion as not to exceed that of a halfpenny piece.

Boiler Explosion at Camerton.—On the 10th ult., one of the boilers at the Camerton Coal Works suddenly exploded. The top part was separated from the bottom, and blown completely over the buildings, and pitched about fifty yards from its original place. One side of it, in falling, shattered the cabin of a boat in the canal, waiting to be loaded. A boy, who was sleeping by the side of the boiler, was so severely injured that he died soon after.

DOCKS, HARBOURS, BRIDGES, &c.

The Tees Breakwater.—The foundation-stone of a new breakwater, at Stockton-on-Tees, has been laid. The plans are for the construction of two curvilinear breakwaters; one line extending from Tod Point, on the southern shore, across the Bran Sand, to the Checkered Buoy, a distance of about 4,300 yards. From the site of the First Black Buoy the line of works will extend over the North Gare—a distance of 2,000 yards, terminating at the Seaton Snook. The entrance to the channel between the ends of the breakwaters will be about 600 yards in width. The total length of the breakwater will be about 6,600 yards, the average height about 15ft., and the width at the top 40ft. The breakwater was commenced at the beginning of the last year, and considerable progress has been made. It is constructed in rubble, the material used being, the slag from the iron furnaces in the district. The slag is moulded into large square blocks, weighing about 3 tons each, and whilst they are in a red-hot state are conveyed to the breakwater and "tipped." The mode of constructing the breakwater is similar to that adopted with the Plymouth and Cherbourg breakwaters. In the conveyance of the slag from the furnaces two locomotives and 500 iron bogies are fully engaged. The amount required to carry out the scheme is estimated at £100,0000, of which £30,000 have been obtained from the Public Works Loan Commissioners. If constructed in stone it was estimated that the building would have cost £600,000.

MINES, METALLURGY, &c.

Slate Quarries in Canada.—Mr. R. Bell, of the Geological Survey, in a paper on this subject, read before the Canadian Natural History Society, says that the annual value of the slates produced in Wales alone is nearly £1,000,000 sterling, and the uett profits of many of the companies engaged in this branch of industry are upwards of 50 per cent. The most important slate-producing district in North America is situated at Vermont. But little of the deposit in Eastern Vermont can be profitably worked "owing to contortions, imperfect cleveage, cross-joints, and the presence of foreign ingredients." Bands suitable for the manufacture of roofing slate were only found occasionally in this district. The quarries in the western part of Vermont appear to be more productive than those in the eastern part of the State. It seems that this slate is used for other purposes than roofing. Mantelpieces, table, and bureau tops, billiard-table beds, and lamp bottoms are manufactured from it. The slates produced from the Northfield Quarries, Vermout, sell at 3½ dols. a "square" delivered in the cars. In Canada the price is 50 cents. less per square, delivered at Richmond. A square of slates is 100 square ft.; and the greater the number of slates making up this area, the less the price. The most important slate quarries in Canada occur in the eastern townships. Geologically speaking, they belong to rocks of the Quebec group. The author described other probably favourable localities for roofing slates in Eastern and Western Canada.

Coal in India.—The only coal field of any considerable extent known at present is that of Ranigunj or Damooda, near Burdwan in Bengal, covering an area of about 500 square miles. There are some 50 collieries in this field producing yearly on an average about 300,000 tons of coal. The description produced is a variety of non-coking bituminous coal; but one great objection to that worked in the Damooda field is the presence of iron pyrities, and its consequent liability to spontaneous combustion, which render it particularly unfitted for steam-ships. The broadest seam yet discovered is at Kasta, where the bed is 35ft. thick. Next in importance to the Ranigunj field are the Nerbudda coal deposits. They are supposed to extend over an area of fully 300 square miles; but their distance at present from any available market makes the out-turn but of little practical use. As, however, iron ore is found to exist in the same locality, the coal will prove serviceable for smelting purposes, and will thus enhance the value of the iron mines. The best coal is found at a place called Mopani, where the beds have an average thickness of from 7ft. to 8ft. A company has already been formed for working these coal and iron deposits, and we have no doubt that, as the railway progresses towards that part of India, the Nerbudda coal fields will afford an ample supply, at a fair profit, to the important lin which in two or three years we may hope to see completed as far as Jubbulpore. No workable coal has been found in the Punjaub, or north-western provinces; a few patches of lignite only have been met with. In Scinde a small mine was opened in the Lynah Valley in 1856, by the railway company there; but, owing to its irregularity and

probable want of sufficient age, it was abandoned. Neither in the Bombay nor Madras Precidencies, nor in the Nizam's dominions, is coal known to exist; and the few black shales met with on the Godavery, which are incapable of combustion, cannot be said to come under the denomination of coal. The entire quantity supplied annually by the Ranigunj, Rewah, Nerbudda, and other Indian coal fields, does not exceed 400,000 tons.

VENTILATING MINES.—To ventilate mines by means of steam and heated air, without the use of open fires and furnaces, has been provisionally specified by Messrs. Evans, of Cefn Mawr, and Griffiths, of Mertbyr Tydvil. They propose to erect, contiguous to the upper part of the upcast shaft, a tower or structure open at the top (except as hereafter stated), and they lead from the lower part of this hot-air tube in communication with a fire-clay pipe, formed at one or each side of this furnace in the form of a channel, the air in the pipe being thus heated in the furnace, and supplying the interior of the tower in the lower part; and they prefer to carry a steam-pipe from the top of the said steam-boiler into an upper point of the interior of the said tower, at the end of which steam-pipe they provide a steam-box, with a ring of jet-pipes projecting upwards, and at the top of the tower there is an inverted cone, for regulating the draught. The bottom of the tower is made inclining to the centre, so as to form a drain, to carry off any condensed water. Instead of placing the furnace and boiler outside the tower, or structure aforesaid, they can have it, or portions of it, placed within the tower.

GAS SUPPLY.

THE HYTHE AND SANDGATE Gas Co. intend reducing the price of gas from 8*s*. to 7*s*. per 1000 cubic feet.

THE CHELTENHAM Gas Co. have decided upon reducing the price of gas to private consumers from 4*s*. 9*d*. to 4*s*. 6*d*. per 1000ft.

THE BIRMINGHAM AND STAFFORDSHIRE GASLIGHT Co. announce that they have decided on making a further reduction in the price of gas, to all parties whose consumption is under 25,000 cubic feet per quarter, the price will be 3*s*. 4*d*. per 1000; 25,000 and under 100,000 cubic feet, 3*s*. per 1000; 100,000 cubic feet and upwards, 2*s*. 8*d*. per 1000. This scale will be subject to a discount of 5 per cent. for cash.

AT KINETON new gasworks have been erected. The contractors were Messrs. Porter and Co., Lincoln. The gross estimated outlay on the works is about £1,200. The plans were prepared by Mr. Lait. The material is blue brick, with white facings, pointed with black mortar. The gasometer is capable of containing 4000 cubic feet of gas. The price of the gas will be about 8*s*. or 8*s*. 4*d*. per 1000ft.

THE WORCESTER GAS COMPANY have resolved to reduce the price of gas to private consumers from 4*s*. 6*d*. to 4*s*. per 1,000 cubic feet. A reduction of the charge for the public lamps 5*s*. per lamp—that is, to £3 5*s*. per lamp per annum—has also been agreed to.

GAS CARBURETTING APPARATUS.—Messrs. Nordhoff and Co., of Nismes, some time since, patented a gas carburetting apparatus, which soon came into use in several large towns in the south of France. This apparatus has been patented in England. One has been exhibited at Messrs. Hartwright and Meyerheim's, 19, Chapel-walks, Pall-mall. The apparatus is intended to be placed near the gasmeter, and its adoption, it is said, will not require the least alteration in the gas-fittings. In outward appearance, the apparatus is described as resembling a meter. The internal arrangements consist simply of a cubic network of worsted wicks, reaching with its ends into some carburetted liquid, which is of a constant level. This network is placed in a cylinder of copper or iron, between two sides pierced with small holes. A tube, also perforated, leads the gas through the network of wicks. The instrument varies in size from 5 lights up to 150 lights.

GAS PRODUCING MATERIAL.—At the inauguration of the Pangbourne village gasworks, Mr. G. Bower, of St. Neots, remarked that he had long come to the conclusion that there is nothing in this country that can compete with coal, be it liquid or solid, for gas making on a large scale, for the elements required to make illuminating gas exists in most coals in the exact proportions required—sufficient hydrogen to heat the carbon, and sufficient carbon to give the light. Cannel coal yields the richest gas, but as the coke from most of it is of little value, and the gas richer than consumers care to pay for, it is only used for mixing with inferior coal. But a great deal depends upon the way in which the gas is burnt to obtain the greatest illuminating power. A poor gas requires less air than a rich one. What would be just enough for the former would be totally inadequate for the latter, for it would smoke, and then people would say "What bad gas it is!" Now, whenever you see ceilings black, suggest a new burner adapted to the character of the gas being burned.

THE PUBLIC LAMP-POSTS AT PARIS, which are of cast-iron, are being coated with copper, by electro-depositing, so as to have all the effect of bronze. The large fountains in the Place de la Concorde have recently been taken to pieces in order to be thus covered. The work is done by M. Oudry, at Auteuil, who is carrying on electro-depositing on a gigantic scale. He has recently completed a full-sized copy in copper deposit of Trajan's column at Rome.

APPLIED CHEMISTRY.

ANOTHER CHROME GREEN.—A brilliant green for printing is said to be made in the following way:—Take 15 parts of bichromate of potash, 36 parts of crystallised phosphate of soda, and 6 parts of tartaric acid. Fuse the phosphate in its water of crystallisation, and add to it the bichromate rubbed to fine powder, and afterwards the tartaric acid. Great frothing takes place on the last addition, and the colour of the mass changes from yellow to green. A porous brown mass remains, which dissolves in hot water and dilute acids, giving an emerald green solution. The porous mass is to be moistened with as much strong hydrochlorate acid as it will absorb; it is then treated with cold water to remove the acid, and afterwards with boiling water to dissolve out the soda and potash salts. An insoluble green body remains on the filter, which, when more finely divided by levigation, becomes of a brighter shade. The 6 parts of tartaric acid may be replaced with 14 parts of Rochelle salt.

MANUFACTURE OF ALUMINIUM.—The process in use at Salyndre Works, as described by Mr. A. Stewart, has been published in a recent issue of the *Revue Universelle*. They are working a very valuable ore, furnishing pure alumina by two very simple operations, which now renders the preparations of aluminium an actual metallurgical operation in the Ollioncilles, near Toulon. Its average composition is—alumina, 60 per cent.; oxide of iron, 25; silica, 3, and water 12 per cent. = 100. After being pulvering under an edge-runner, it is mixed with soda, and heated in a reverberatory furnace. The mass, although not even agglutinating, becomes changed into an aluminate of soda, and a double silicate of soda and alumina is obtained, mixed with oxide of iron, silica, and a little of the alumina which has not re-acted. The aluminate of soda is dissolved out with water (the impurities remaining undissolved), and thrown in fine streams through a current of carbonic acid, by which means alumina is thrown down, and carbonate of soda remains. The precipitated alumina is separated by decantation, and washed with warm water to remove the last traces of soda. In practice no soda is lost, except a small portion converted into silicates, the remainder being recovered by evaporation. The alumina is completely dried, and is ready for final treatment. The manufacture of the sodium has been but little modified. The final re-action which yields the aluminium is effected in a reverberatory furnace. To the double chloride of aluminium and sodium is added about 5 per cent. of sodium; and, lastly, cryolite as a flux. By this means the metallic aluminium is economically and speedily obtained.

NEW ELEMENTARY BODY.—Messrs. Reich and Richter have found a new elementary body in the arsenical pyrites of Freiberg, Saxony. They call it *indium* because under the spectrum it shows no green but an indigo ray hitherto unknown, very bright, very distinctly marked, and of more refrangibility than the blue ray of the strontium. They are reported to have isolated this body in very small quantity, in the shape of chloride, of hydrate of oxide, and even in metallic state; to have ascertained that indium is not precipitated by the sulphuretted hydrogen from an acid solution of its chloride, that, on the contrary, it is precipitated by ammoniac in the state of hydrate of oxide; that the chloride is exceedingly diliquescent; that the oxide, when heated in contact with coal and soda, gives very soft and ductile grains; that these, if exposed to the blow-pipe, leave only a yellow slag, which, if re-heated, does not colour in a cobalt solution.

ON THE OXIDATION OF ALCOHOLS, BY M. BERTHELOT.—The experiments recently published by MM. Wurtz, Wanklyn, Erlenmeyer, and Friedel on the alcohols derived from anylene, hexylene, and acetone, have induced me to re-study the alcohols I had obtained synthetically eight years ago by means of olefiant and propylene gases. I have been unable to find any difference between alcohol derived from olefiant gas and ordinary alcohol, either in their physical and chemical properties, or as regards their ethers. I will mention as especially characteristic the identity of the crystalline form of ethyl-sulphate of baryta, whether derived from ordinary alcohol or from olefiant gas. To these tests, which are now old, I have added experiments in oxidation. Treated by chromic acid, the alcohol of olefiant gas furnished perfectly characterised ordinary aldehyde and acetic acid, that is to say, the same products as ordinary alcohol. Submitted to these new tests, rendered necessary by the recent progress in science, the identity of the two alcohols is entirely established. Propylic alcohol, on the contrary, as I have several times shown, possesses different properties, according to whether it is produced by fermentation or prepared by means of propylene. According to M. Friedel, alcohol obtained by means of acetone would represent a third type differing from the preceding. I have examined the oxidation of propylene alcohol. Treated by chromic acid it is attacked energetically, forming acetone, and an acid which for want of material I have not yet been able properly to examine. The formation of alcohol at the expense of propylene alcohol is the result of a simple dehydrogenation—

$$\underbrace{C_6H_8O_2}_{\text{Propylic alcohol.}} - H_2 = \underbrace{C_6H_6O_2}_{\text{Acetone.}}.$$

This proves that propylene alcohol is identical with that obtained by hydrogenating acetone. In fact, propylene alcohol, says M. Friedel, regenerates acetone precisely under the influence of a mixture of sulphuric acid and bichromate of potash. The relations between acetone and the propylic series are thus corroborated—relations which were foreshadowed during my experiments on the formation of propylene, C_6H_6, and of its hydride, C_6H_8, and at the expense of acetone treated by sulphuric acid, and which are decisively established by M. Friedel's beautiful researches. The origin of propylic alcohol which has formed acetone, gives to my present experiment a more general signification, especially if it approaches the abnormal characters assigned by MM. Wankly and Erlenmeyer to aldehyde and hexylic alcohol. In fact, acetones and various pyrogenated bodies accompanying them possess most of the properties of aldehydes. This analogy is explained by the present experiment, which tends to prove, starting from the propylic series, that acetones and allied pyrogenous bodies represent the aldehydes of alcohols formed by the hydration of carbides of hydrogen.

ON THE NON-EXISTENCE OF WASIUM AS A SIMPLE BODY, BY M. J. NICKLES.—Wasium has been described by M. Bahr as existing in Norwegian orthite, in that of the island of Rœnsholm, as well as in the orthite of Ytterby. He finds it in the state of oxide associated with silica, alumina, sesquioxide of iron, yttria, ceria didymia, lime, manganese, and with traces of uranium, thorina, and tantalum. These minerals contain hardly more than 1 per cent. of wasa (oxide of wasium). The properties indicated by M. Bahr as characteristic of the new metal seem to us to present no very novel peculiarities. Its examination, on the contrary, leads to the conviction that instead of containing a new simple body, wasium is only a complex oxide, the elements of which are known; it is yttria coloured with a little oxide of didymium or terbium. Wasium itself is then nothing more than yttrium containing a little of its congeners didymium or terbium, as shown in the following table, in which to facilitate comparison, the properties supposed to charactersie wasium are in juxtaposition to those which on the authority of observations made by Gadolin, Eckeberg, Klaproth, Vauquelin, Berzolius, Wœhler, Berlin, and Mosander, warrant the autonomy of yttrium:—

Oxalic acid and oxalates in acid solution	White precipitate	White precipitate.
Ammonia	Imperfectly pecipitated	Imperfectly precipitated yttria not being insoluble in ammoniacal salts.
Caustic potash	White precipitate insoluble in an excess	White precipitate insoluble in an excess
Sulphate of potash	Crystalline white precipitate	Crystalline white precipitate.
The blow-pipe with borax, with oxidising and reducing flame	Transparent and pearl-like	Transparent and pearl-like.
The button exposed to the intermitting flame of a blow-pipe becomes	White	White.

To this it must be added that nitrate of wasia has precisely the same rose colour as nitrate of yttria, when, as Mosander has proved, this salt contains didymium, or, according to Berzelins, terbium. Its aqueous solution furnishes, by evaporation, a gelatinous precipitate, similar to Klaproth's nitrate of yttria. Under the influence of chlorine, charcoal, and a high temperature, it gives a white sublimate of volatile chloride, while the *caput mortuum* retains a fixed chloride neither more nor less than yttrium, which, according to M. Wœhler, volatilises only partially under these circumstances, a portion remaining in the residuum even at a very high temperature, which agrees with Berzelius's observation that chloride of yttrium is not volatile. The resemblance between the two bodies being perfect, it is evident that wasium is impure yttrium. The brown colour of its oxide, and the rose tint of its salts, favour the suspicion of the presence of a little didymium, and probably of terbium also, the congener of yttrium, being isolated with much difficulty, and distinguished in its acid solutions by a red tint.

AZULENE; ITS OPTICAL PROPERTIES, BY SEPTIMUS PIESSE, F.C.S.—Two blue oils from the *Matricaria Chamomilla* and the *Achillea Millefoila* which have been shown by Piesse to owe their colour to the peculiar principle azulene, have been examined by Sir D. Brewster. He says:—"They differ from all the various bodies which I have yet examined. Between the two lines A and B of Fraunhofer's map of the spectrum—there are two groups of lines shown in that map—the two ottoes absorb the light in these portions more powerfully than in the portions adjacent to them. No other fluid or solid on which I have made experiments acts in a similar manner; but what is very remarkable, the earth's atmosphere exercises a similar action when the sun's light passes through its greatest thickness at sunrise and sunset."

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated November 24th, 1863.

2949 G. W. Yapp—Preservation of animal substances.
2950 St. G. Gregg & T. Gray—Production of thread cordage and woven textile fabrics.
2951 D. W. Ren—Preserving animal and vegetable substances.
2952 W. Howlett—Printing floor cloths, carpets, and similar goods.
2953 C. Schiele—Hydraulic apparatus.
2954 G. Davies—Photography.
2955 J. Lewis—Driving sewing machines.
2956 J. H. Johnson—Improvements in rotatory engines.
2957 R. Furnival—Improvements in braiding machines.
2958 W. E. Newton—Breaking and cleaning flax and hemp.
2959 W. E. Newton—Balloons.
2960 J. Sibert—Joined blond.
2961 P. Tait—Ironing garments.
2962 C. L. Daboll—Marine fog signals.

Dated November 25th, 1863.

2963 G. Parkin—Oils.
2964 T. Wilson—Cutting, perforating, and shaping metals.
2965 M. Puwer—Fire escapes.
2966 E. Bevan—Manufacture and application of gases.
2967 L. Accarain—Manufacture of paper, thread, cordage, and fabrics.
2968 J. H. Wilson—Ship and other lift pumps.

Dated November 26th, 1863.

2969 H. B. Barlow—Improvements in looms for weaving.
2970 D. Kircaldy—Testing the strength and other properties of various materials and structures.
2971 R. Laming—Preparing materials for purifying gas.
2972 J. Thorpe—Marking patterns or designs upon skirtings.
2973 J. Simmonds—Stink traps.
2974 J. Baker—Compositions for coating ships' bottoms.
2975 J. Nadal—Apparatus for raising and forcing fluids.
2976 J. S. Jarvis—Shirt collar.
2977 J. Chesterman—Frames for umbrellas.

Dated November 27th, 1863.

2978 J. A. R. Main—Connecting and sustaining the intersecting bars of iron fences.
2979 W. C. Brocklehurst & J. & J. Creighton—Winding threads.
2980 T. Gray—Discharging colour from rags.
2981 F. Page—Manufacture of volatile hydrocarbons.
2982 J. & D. Bateman—Improvements in sewing machines.
2983 C. Crabtree—Manufacture of paper spool tubes.
2984 J. Clark—Improvements in looms for weaving elastic fabrics.
2985 J. Clark—Cutting strips or threads of india rubber.
2986 E. Gardner—Improvements in looms for weaving elastic fabrics.
2987 H. Hirzel—Extracting oils.
2988 S. & T. Smith—Destroying insects.
2989 P. Gaskell—Indicator for cabs and other public vehicles.

Dated November 28th, 1863.

2990 E. Bevan & W. S. Weare—Watches.
2991 C. Cordon—Supplying water to water closets and urinals.
2992 E. Ironmonger—Fitting together or connecting articles or parts of articles.
2993 T. Laue—Chaff-cutting machinery.

Dated November 30th, 1863.

2994 A. l'Etienne—Construction of carriages and vehicles.
2995 A. Albini—Ships of war and arming the same.
2996 G. A. & G. A. Thompson & J. Latham—Door springs.
2997 W. Campion, G. Wilson, & A. Wilson—Self-acting time register.
2998 M. R. Pilon—Fire-arms.
2999 J. Chalmers—Guns and gun projectiles.
3000 E. W. James—Boring rock and other earthy substances.
3001 J. Fernie & G. Taylor—Shaping the edges of boilers.
3002 J. M. Ollis—Obtaining fresh water from sea water.
3003 C. Pontifex—Construction of sluice and other cocks.
3004 J. E. & E. H. Blundon—Construction of letter and other bags.

Dated December 1st, 1863.

3005 E. M. Boxer—Improvements in fuzes and shells for ordnance.
3006 H. Wilde—Construction and working of electric telegraphs.
3007 P. G. Gardiner—Improvement in railroad car springs.
3008 R. Brailsford—Improvements in the construction of vermin traps.
3009 B. Jones—Separating sulphur from alkali waste.
3010 G. J. Doddrell—Improvements relating to the manufacture or refining of sugar.
3011 W. E Gedge—Plough.
3012 J. G. Redman & G. Martin—Compositions for coating ships and vessels.
3013 H. Lumley—Improvements in apparatus for steering.
3014 R. Turnbull—Sheathing iron vessels and armour plated ships.
3015 W. Clark—Improvements in apparatus for lighting and heating.
3016 E. A. Inglefield—Mounting and working guns.
3017 G. Glover—Dry gas meters.
3018 J. Thom—Apparatus for expressing oils and fatty matters.
3019 T. Mallinson—Self-acting mules for spinning cotton.
3020 S. B. Cochran—Improvements in sewing machines.

Dated December 2nd, 1863.

3021 G. Macfarlane—Improved ink regulator and indicator.
3022 R. Lublinski—Bending the reverse ends of partridge canes.
3023 W. Wilson—Generating gas for illuminating and other purposes.
3024 T. Snook—Causing a stronger current of air to fires.
3025 J. Dales—Fitting movable or travelling frames and surfaces
3026 J. Capper—Curing smoky chimneys and preventing down draughts therein.
3027 A. W. Haley, A. Bingham, & R. Webster—Making envelopes.
3028 T. T. England—Lubricating the shafts of the conducting pulleys of mules
3029 H. Holdrege—Gas for illuminating and other purposes.
3030 S. Trotman—Improvements in the manufacture of soap.
3031 J. Harper—Improvements in pillars and apparatus for straining wire.
3032 R. L. Clifton—Improvements in apparatus used when brewing.
3033 J. Cutler—Apparatus for lighting and ventilating.
3034 T. Harrison—Machinery for cutting coal and other minerals and stones.
3035 H. D. P. Cunningham—Reefing and furling topsails, topgallant sails, and royals.
3036 C. Langley—Construction of ships of war and other vessels.
3037 R. A. Brooman—Treatment of bituminous substances.
3038 C. Cammell & W. Crompton—Railway crossings.
3039 W. E. Newton—Improvements in printing machinery.

Dated December 3rd, 1863.

3040 T. Knowles—Manufacture of rollers used by calico printers.
3041 J. Green—Horse shoes for hunting and other purposes.
3042 D. Hulett—Gas stoves.
3043 E. Stevens—Improvements in cooking apparatus.
3044 J. Bowron & G. Robinson—Soda and sulphuric acid.

Dated December 4th, 1863.

3045 E. J. Hughes—Producing aniline black on cotton fabrics or yarns.
3046 J. Robbins—Obtaining oxygen gas.
3047 R. Riley—Carding engines.
3048 J. Corbett—A combined hot-water and hot-air stove.
3049 W. Williamson—Improvements in wringing machines.
3050 J. Green—Construction of barrows, cultivators, and ploughs.
3051 R. A. Brooman—Railway brakes.
3052 R. Hornsby—Threshing and screening wheat and other grain
3053 T. Douglas—Combs.
3054 R. Hornsby & J. E. Phillips—Reaping and mowing machines.

Dated December 5th, 1863.

3055 S. A. & C. F. Varley—Heating.
3056 J. Conlong—Opening, cleaning, and preparing cotton.
3057 W. Gorman & J. Paton—Obtaining and applying heat.
3058 G. Wilson—Looms.
3059 H. A. Bonneville—Saws.
3060 S. Smith—Improvements in hydraulic pressure gauges.
3061 F. J. Walthew—Preventing draught horses from falling or injuring the vehicle to which they are attached.
3062 J. H. Johnson—Washing fabrics.
3063 J. A. Wanklyn—Manufacture of yellow and orange colours.

Dated December 7th, 1863.

3064 J. F. Hallet & T. L. White—Apparatus for checking cash taking at intervals.
3065 A. J. Aspinall—Hand stump.
3066 W. & S. Firth & J. Sturgeon—Cutting and boring coal.
3067 A. Antill & W. Wilkinson—Joints and catches for brooches.
3068 J. H. Simpson—Manufacture of boots and shoes.
3069 F. Piercy—Application of heat to water and other fluids.
3070 R. A. Brooman—Crinolines.
3071 M. Turnor—Pencil cases.
3072 R. Richards & S. C. Willetts—Breech-loading fire-arms.
3073 G. R. Tilling & J. Park—Steering gear for ships and other vessels.
3074 E. Clifton—Preparing and combing wool and other fibrous substances.
3075 T. Bate—Covers of receptacles for containing biscuits, fruits, and other articles.
3076 W. C. Page—Preventing the incrustation of steam boilers.
3077 C. Brown—Elastic bands.

Dated December 8th, 1863.

3078 J. Flearman—Crinoline.
3079 W. Wanklyn—Ginning cotton.
3080 G. C. Grimes—Fusees.
3081 J. H. Brierley—Buckles.
3082 H. B. James—Covering steam boilers.
3083 J. Aubert—Railway brakes.
3084 J. Wray—Spindles.
3085 R. Thornton—Bridges.
3086 M. Guthrie—Stamp.
3087 T. A. Blakely—Projectiles.
3088 T. A. Blakely—Metallic packings.
3089 P. H. Desvignes—Exhibiting dissolving views
3090 R. Harrowby, J. Foulds, & A. Hurrowby—Looms.
3091 H. Eastwood & B. Matthews—Carding wool.
3092 J. E. Boyd—Grass cutting machines.
3093 T. Harrison—Puddling iron and steel.
3094 P. R. Wason—Heating and ventilating horticultural buildings.
3095 W. M'Intyre Crauston—Reaping and mowing machines.
3096 M. Henry—Regulating the passage of aeriform and other fluids.
3097 J. Tod—Treatment of flock.
3098 E. N. Gregory—Driving bands and pulleys.
3099 A. V. Newton—Preparing cork stuffing.
3100 W. L. & T. Winans—Screw propellers.

Dated December 9th, 1863.

3101 H. Audinwood—Removing grain.
3102 T. H. Fletcher & R. Forrest—War rocket.
3103 W. H. Cole—Casting steam cylinders.
3104 W. Macklin—Reversing the motion of steam engines.
3105 J. Wright—Furnaces, fire grates, and bars.
3106 T. Perks—Fastenings for brooches.
3107 T. V. Morgan—Treatment and purification of plumbago.
3108 N. Kennedy—Fire-arms.
3109 M. Hillary—Fastenings for doors.

Dated December 10th, 1863.

3110 W. & J. Galloway—Presses for bending metal plates.
3111 H. Turner—Preventing boiler explosions.
3112 M. Friedlander—Treatment of tow.
3113 A. Reid & G. Rydill—Rug machine.
3114 J. A. Pols & P. O. Bernard—Obtaining oils.
3115 W. Clark—Port closers.
3116 G. T. Bousfield—India rubber and gutta percha compounds.
3117 R. W. Pyne—Shutter fastener.

Dated December 11th, 1863.

3118 E. Darwen & J. Haddon—Nails and rivets.
3119 S. Tuchet—Roller for window blinds.
3120 J. Bullough—Looms for weaving.
3121 W. Livingstone—Screw propeller.
3122 C. Seaton—Permanent way of railways.
3123 J. Corby—Centrifugal machines.
3124 A. Epps—Malt and hop kilns.
3125 E. Shepherd—Cocoa nut fibre for matting.
3126 T. Webb—Engines.
3127 H. Kinsey—Bonnet front machines.
3128 N. Walton—Washing, wringing, and mangling machines.
3129 J. Cliff—Transmitting motive power.
3130 J. Cliff—Lamps.
3131 E. Solvay—Carbonate of soda.
3132 R. A. Brooman—Nuts.
3133 R. A. Brooman—Colouring wall paper.
3134 E. & W. Ullmer—Printing machines.
3135 W. T. C. Pratt—Railway points.

Dated December 12th, 1863.

3136 T. Clayton—Generators.
3137 J. Townsend—Dressing and drying fibrous materials.
3138 J. C. Wilson—Unhusking seeds.
3139 B. Dobson, J. Hodgkinson, & F. Hamilton—Carding cotton.
3140 R. A. Brooman—Steam engines.
3141 J. H. Johnson—Attaching soles to boots.
3142 J. H Johnson—Raising sunken and preventing the sinking of vessels.
3143 R. H. Ray—Sauce.
3144 R. Saunders—Rendering ships' cables less likely to part during heavy riding.
3145 J. Platt & W. Richardson—Preparation of clay.
3146 W. T. W. Jones—Apparatus for lamps.
3147 G. T. Bousfield—Washing machinery.
3148 P. Ward—Packing parts of machinery.
3149 G. T. Bousfield—Fulling machinery.

Dated December 14th, 1863.

3150 C. Stewart—Boots and shoes.
3151 J. A. Bailey & J. J. Speed—Covering wire.
3152 J. Wright—Superphosphate of lime.
3153 W. Spence—Calendering machines.
3154 R. Rascol—Glass.
3155 S. and T. Smith—Lozenges.
3156 R. A. Brooman—Ships' cooking and distilling apparatus.
3157 S Edwards—Grinding pearl.
3158 B. Fothergill—Combing wool.
3159 T. Wilson—Fire-arms, projectiles, and cartridges.
3160 W. H. Thornthwaite—Chromate of potash.

Dated December 15th, 1863.

3161 H. B. Sears—Cleansing grain.
3162 V. De Stains—Propelling vessels.
3163 V. Obert—Toy.
3164 L. Nobel—Strengthening guns.
3165 W. W. Box—Fire bars for engines.
3166 J. Davidson—Casks.
3167 J. H. Johnson—Grinding and polishing glass.
3168 H. Chadwick and J. Clench—Utilizing the waste liquors from fibrous matters.
3169 A. Starck—Paper.
3170 C. J. Robinson—Pressing cotton into bales.
3171 J. Smith—Breech-loading fire-arms.
3172 J. M. Bryden—Painting Venetian blinds.
3173 J. M. Worrall—Producing a superior finish upon woven fabrics.
3174 J. Sellars—Food for cattle.
3175 J. Hindle, W. F. Calvert, and E. Thornton—Looms.
3176 E. R. Hollands—Punching apparatus.
3177 J. Gouvernon—Watches.
3178 R. A. Brooman—Working railway signals.
3179 T. A. Blakely—Ordnance.
3180 E. Myers and H. D. Cloag—Rotary pumps.
3181 A. V. Newton—Sewing machinery.
3182 J. B. Fell—Railway engines.
3183 C. Humfrey—Dissolving india rubber.

Dated December 17th, 1863.

3184 G. H. Ellis—Bottle cases.
3185 R. Marrison—Fire-arms.
3186 W. Clark—Indicating the level of water in steam boilers.
3187 C. Jeffreys—Jewel, photograph, instrument, and other cases.
3188 J. H. Johnson—Cleaning roadways.

Dated December 18th, 1863.

3189 J. Astbury—Forge hammers.
3190 W. Clarke—Ropes.
3191 A. Alison and J. Halliwell—Atmospheric railways.
3192 P. Gardner—Ordnance and projectiles.
3193 T. Hyatt—Sliding window shutter.
3194 P. M. Parsons—Fire-arms and projectiles.
3195 W. B. Adams—Locomotive engines.
3196 R. Saunders—Portable cottages.
3197 H. A. Bonneville—Letter-boxes.
3198 H. A. Bonneville—Socks.
3199 H. Clayton—Bricks.

Dated December 19th, 1863.

3200 J. Mccarthy—Taps.
3201 W. Noton—Opening and scutching cotton.
3202 R. Legg—Shot-proof iron or steel walls.
3203 T. Goldie—Looms for weaving.
3204 E. T. Hughes—Printing ink.
3205 F. W. Collins—Training hops.
3206 W. E. Gedge—Decanting liquids.
3207 G. Haseltine—Oil.
3208 F. N. Gisborne—Signals.
3209 C. Bolton—Producing optical illusions.
3210 F. Walton—Floor cloths.
3211 C. T. Judkins—Sewing machines.
3212 J. Howden—Steam engines and boilers.
3213 W. H. Tooth—Iron and steel.

Dated December 21st, 1863.

3214 I. Coombs and J. T. Pendlebury—Cutting and bending wire.
3215 W. J. Dixon—Oil cans.
3216 W. Clark and W. F. Batho—Rolling roads.
3217 E Tangye—Welded iron and steel chains
3218 R H Taylor—Lubricating cylinders
3219 R Paterson—Steam engines
3220 E Wilson and G Lindsley—Boilers
3221 R Baynes—Darning stockings
3222 F H Fitzwilliam—Steering ships
3223 J Green—Harrows, cultivators, and ploughs
3224 E J Green and R Mason—Holder for cotton reels
3225 J Eastwood—Forcing glutinous substances through pipes
3226 M Henry—Controlling the passage of fluids
3227 J L Wittenberg—Envelopes
3228 M Henry—Houses
3229 V B F Gibbon—Spring mattresses
3230 A V Newton—Cotton gins
3231 W L and T Winans—Trimming ships

Dated December 22nd, 1863.

3232 J Shanks—Soda and potash
3233 D Adamson—Steel and iron
3234 J Sainty—Turnip cutter
3235 J G Rowe—Communication between the guard and engine driver of a railway train
3236 R A Brooman—Feeding steam boilers
3237 F Hazeldine—Hydraulic pumps
3238 W E Gedge—Knives for rag cutting
3239 H Emanuel—Protecting articles in shop fronts
3240 J Gjers—Lifts
3241 A Turner—Looms

Dated December 23rd, 1863.

3242 J H Johnson—Tips for boots
3243 A M Twining—Preventing railway accidents
3244 R E V Hees—Securing the ends of bands in bale goods
3245 R Walter—Safety cabs
3246 J Ronald—Conversion of rope into oakum
3247 W E Gedge—Fixing candles upright in candlesticks
3248 J Knowles—Removing the sediment from steam boilers
3249 J Mathew—Batteries
3250 W Clark—Igniting the charges of explosive projectiles
3251 G T Bousfield—Forging and tempering bayonet blades
3252 F Walton—Improvements in telegraph cables
3253 W E Newton—Improvements in breech-loading fire-arms
3254 S B Ardrey, S Beckett, and W Smith—Lathes for turning
3255 W Holland—Improvements in looms for weaving
3256 J H Johnson—Improvements in tips for boots and shoes

THE ARTIZAN.

No. 14.—Vol. 2.—Third Series.

FEBRUARY 1st, 1864.

ON THE PRESSURE OF STEAM AT HIGH TEMPERATURES.

By R. A. Peacock, C.E.

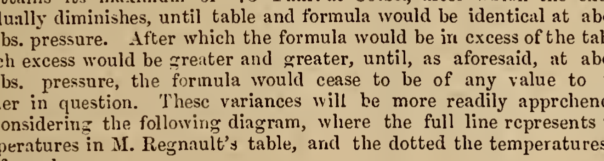
(*Continued from page* 3.)

The reader has now the means of forming his own opinion as to the degree of reliance which can be placed on the formula. That is to say, if he accepts Dr. Fairbairn's temperatures with the respective pressures of 56·7 and 60·6lbs., and discards M. Regnault's temperatures, which are about $\frac{2}{3}$ of a degree Fahr. greater for equal pressures, then the formula will be as accurate as could be expected or even wished for. Because we should have as follows:—

Pressure.		Temperature. Fahrenheit.	Formula.	Differences.
lbs. per sq. in.				
30	M. Regnault	250·23	250·17	+·06
56·7	Dr. Fairbairn	288·25	288·20	+·05
60·6	Ditto	292·53	292·48	+·05
300	M. Regnault	417·50	417·32	+·18
336·3	Dr. M. Rankine*	428·00	428·05	−·05

* This is supposing Dr. Marquorn Rankine's to be an experiment and not a calculation.

These differences are exceedingly small. But, if on the other hand, any reader rejects Dr. Fairbairn's experiments aforesaid and adopts M. Regnault's table throughout, the formula will be valueless to him for pressures greater than about 400lbs. to the square inch. Because M. Regnault's table gives a temperature less than the formula by ·24 for 25lbs., this difference gradually diminishes with increasing pressures until at 29lbs. the table and the formula are exactly equal. With higher pressures the table gives temperatures in excess of the formula, which excess gradually increases until it attains its maximum of ·73° Fahr. at 80lbs., after which the excess gradually diminishes, until table and formula would be identical at about 320lbs. pressure. After which the formula would be in excess of the table, which excess would be greater and greater, until, as aforesaid, at about 400lbs. pressure, the formula would cease to be of any value to the reader in question. These variances will be more readily apprehended by considering the following diagram, where the full line represents the temperatures in M. Regnault's table, and the dotted the temperatures of the formula:—



By which it will be seen that the formula, after about 400lbs., will necessarily diverge more and more from the table. The diagram shows the *manner* of the discrepancy, greatly exaggerated in *degree.*

The formula is as follows:—It has been stated that the temperature increases as the $4\frac{1}{2}$ root of the pressure in lbs. per square inch. Now for a pressure of 29lbs. to the square inch both M. Regnault's table and the formula give the same temperature, viz., 248·3°, let it therefore be assumed accordingly as a basis to commence from. We shall then have by the formula, supposing the temperature to give a pressure of 300lbs. is required—

$$\frac{\text{log. of 29lbs.}}{4·5} : \text{log. of } 248·3° :: \frac{\text{log. of 300lbs.}}{4·5} : \text{log. of } 417·32°$$

which is the temperature required, as per table appended hereto. But this process may be shortened. The following is the working formula, and gives the same results with half the labour, which is of importance where the calculations are numerous. By it the following table was calculated. No basis is required, the temperature is ascertained at once by adding the constant log. 2·07, which is equivalent to adding the second term and deducting the first.

Working Formulæ.

When the temperature to produce a given pressure is required:—

Rule.—Divide the log. of the given pressure by 4·5, and add log. 2·07; the sum is the log. of the temperature required.

Example.—Required, the temperature to produce a pressure of 29lbs. per square inch?

$$\frac{\text{log. of 29lbs.}}{4·5} + \text{log. } 2·07 = \text{log. of } 248·3° \text{ the temperature required.}$$

Or when the pressure produced by a given temperature is required, we have only to reverse the operation. Thus, let it be required what pressure per square inch will a temperature of 417·32° Fahr. produce? Here we have

$$\text{log. of } 417·32° - \text{log. } 2·07 \times 4·5 = \text{log. of } 299·93\text{lbs.* the pressure required.}$$

Or, again, let it be required what will be the pressure of steam of a temperature of 3,000° Fahr, which Sir W. G. Armstrong assumed as the temperature of subterranean fusion in his address to the British Association.

$$\text{log. of } 3{,}000° = 3·4771213 - 2·07 = 1·4071213 \times 4\tfrac{1}{2} = 6·3320458 = 2{,}148{,}050\text{lbs.} = 959 \text{ tons per square inch,}$$

if the formula can be depended on so far, and it would be difficult to prove either an affirmative or a negative, if we adopt Dr. Fairbairn's experiments.

It thus appears that by first ascertaining the temperature of saturated steam in a boiler, we at once get the pressure. Professor Daniell, F.R.S., ascertained the heat of a common fire to be 1,141° Fahr.; this would give by the formula a pressure of upwards of 12 tons per square inch. Now, supposing an ordinary boiler, made of $\frac{3}{8}$ boiler plate; of course the strength of the plates would be reduced in strength at the joints by the rivet holes, and additionally by the length of the boiler, if that was considerable—short boilers being much stronger than long ones—a plate here and there would also be sure to be defective. All this being considered, there is no reason for surprise that such boilers should burst where the pressure may be of any amount up to, and even exceeding, 12 tons per square inch. At the same time, it is probably quite true that explosions sometimes take place from other causes than excessive pressure of steam directly on boiler plates.

Dr. Fairbairn's experiments on the tensile strength of rivet iron prove that iron may be heated up to about 400° Fahr. without impairing its strength.† This temperature gives a pressure of 250lbs. per square inch. Now, if steam can be conveniently and economically heated up to this point (which ought not to be exceeded), it follows that boilers might be made much smaller than they are at present, where the pressure often does not exceed one-tenth part of 250lbs. In that case, of course, the boilers must be made much stronger; they might, in fact, be made of thin armour plates of Bessemer's steel, joined together with double rows of rivets first, and then be properly bound together with steel bars.

To ascertain the steam pressure correctly, the following plan might be adopted. Provide a coiled steel spring suitably strong, carrying an index, and contained in a case or cavity like an ordinary letter weigher. Place actual weights of different amounts on the top of the brass piston, and graduate accordingly. This will prevent mistakes about the actuality of the pressure indicated. Insert the top of this piston of one inch square, on which the steam is to act, through the top plate of the boiler, and fix the instrument firmly there in an inverted position, the index and spring being outside the boiler. The piston may work through a stuffing box. In like manner a thermometer may be affixed, the bulb being inside the boiler. Thus the pressure and temperature can both be read off. The pressure, as has been said, must not be allowed to get above the 250lbs.,

* The correct temperature by the rule for 300lbs. is not 417·32°, but 417·3[illegible]

† "Useful Information for Engineers," second series, p. 12[illegible]

4

so that the boiler would be quite safe from bursting. This plan would apparently settle the question of boiler explosions; and, the boiler being small, it would not be out-of-the-way expensive, notwithstanding its being made of steel and unprecedentedly strong. In this case the specific volume of the steam, or the ratio of the volume of the steam to that of the water which produced it, would be, according to Dr. Fairbairn's formula, 123·76.

For the purpose of exhibiting in the following table that the temperature gradually increases with the pressure, which ought clearly to be the case if the calculations are correct, the whole of the calculations are given. This will also enable any one to make a comparison between the best known experiments and the calculations.

Table of Pressures and corresponding Temperatures of Saturated Steam, calculated on the theory that the temperature increases as the 4½ *root* of the pressure, and conversely that the pressure increases as the 4½ *power* of the temperature.

Pressure.	Calculation.	Pressure.	Calculation.	Pressure.	Calculation.
lbs. ⅌ sq. in.	Temp. Fahr. deg.	lbs. ⅌ sq. in.	Temp. Fahr. deg.	lbs. ⅌ sq. in.	Temp. Fahr. deg.
25	240·24	49·4	279·50	110	333·92
26	242·34	50	280·25	110·25	334·08
26·5	243·37	51	281·49	115	337·24
27	244·39	51·45	282·02	115·1	337·30
27·4	245·19	51·7	282·34	120	340·44
27·6	245·59	52	282·70	124·95	343·51
28	246·37	52·52	283·33	125	343·54
28·83	247·98	53	283·90	129·8	346·43
29	248·30	54	285·08	130	346·55
29·4	249·05	55	286·25	132·3	347·90
30	250·17	55·9	287·28	135	349·47
31	252·01	56	287·40	139·65	352·11
31·458	252·83	56·7	288·20	140	352·30
32	253·81	57	288·53	145	355·06
33	255·53	58	289·65	145·8	355·50
33·1	255·71	58·8	290·53	147	356·14
33·71	256·74	59	290·75	150	357·75
34	257·23	60	291·84	154·3	360 (1)
35	258·90	60·4	292·27	160	362·91
36	260·52	60·6	292·48	163·3	364·56
36·75	261·70	65	297·08	165	365·40
37	262·11	66·15	298·23	170	367·84
37·8	263·36	67·23	299·31	170·99	368·31
38	263·67	69·21	301·25	180	372·54
39	265·57	70	302·01	182·4	373·63
39·25	265·57	73·5	305·30	190	377·04
40	266·70	75	306·67	195	379·22
40·3	267·14	79·03	310·26	200	381·37
41	268·16	80	311·10	203·3	382·75
41·7	269·17	80·85	311·83	210	385·52
42	269·60	85	315·32	220	389·52
42·196	269·88	88·2	317·92	225	391·48
43	271·02	89·86	319·24	225·9	391·82
44	272·40	90	319·35	230	393·39
44·1	272·54	95	323·22	240	397·13
45	273·77	95·516	323·61	250	400·75
45·49	274·43	95·55	323·63	252·619	401·68
45·7	274·70	100	326·92	254·089	402·20
46	275·11	101·9	328·28	255	402·52
47	276·42	102·9	329·01	260	404·26
48	277·72	105	330·49	270	407·67
49	279·	108·4198	332·84	272·008	408·33

(1) Soft solder, two parts tin and one part lead, melts at 360°.

Pressure.	Calculation.	Pressure.	Calculation.	Pressure.	Calculation.
lbs. ⅌ sq. in.	Temp. Fahr. deg.	lbs. ⅌ sq. in.	Temp. Fahr. deg.	⅌ sq. in. tons lbs.	Temp. Fahr. deg.
280	410·97	980	542·90	6¾	997·21
285	412·60	1000	545·34	7	1005·31
290	414·19	1050	551·28	7¼	1013·17
300	417·32	1100	557·01	7½	1020·84
315	421·87	1120, ½ ton	559·25	7¾	1028·30
316·858	422·42	1200	567·89	8	1035·58
330	426·25	1279·09	576· (2)	8¼	1042·69
336·3	428·05	1300	578·08	8½	1049·63
345	430·48	1400	587·68	8¾	1056·41
351·8298	432·36	1500	596·76	9	1063·05
360	434·58	1600	605·38	9¼	1069·54
375	438·54	1680, ¾ ton	611·98	9½	1075·90
400	444·87	1700	613·59	9¾	1082·13
420	449·72	1800	621·43	10	1088·23
440	454·40	1900	628·94	10¼	1094·22
450	456·67	1984	635 (3)	10½	1100·10
460	458·91	2000	636·15	10¾	1105·86
480	463·27	2055	640 (4)	11	1111·53
500	467·49	2100	643·09	11¼	1117·09
520	471·58 (1)	2200	649·77	11½	1122·56
540	475·55	2240, a ton	652·37	11¾	1127·94
550	477·49	Tons. lbs.		12	1133·23
560, ¼ ton	479·41	1 152	662 (5)	12¼	1138·43
580	483·16	1¼	685·54	12 839	1141 (9)
600	486·82	1½	713·89	12½	1143·50
620	490·38	1¾	738·77	12¾	1148·60
635	492·99	2	761·02	13	1153·56
650	495·56	2¼	781·20	13¼	1158·46
660	497·24	2½	799·71	13½	1163·28
680	500·55	2½ 73	802 (6)	13¾	1168·03
700	503·78	2½ 332	810 (7)	14	1172·72
720	506·95	2¾	816·82	14¼	1177·34
740	510·04	3	832·77	14½	1181·90
750	511·57	3¼	847·72	14¾	1186·40
760	513·08	3½	861·80	15	1190·84
780	516·04	3¾	875·11	15¼	1195·22
800	518·96	4	887·75	15½	1199·54
820	521·81	4¼	899·79	15¾	1203·82
840	524·61	4½	925·37	16	1208·04
850	526	4¾	922·30	17	1224·42
860	527·36	5	932·88	18	1240·07
880	530·06	5¼	943·05	19	1255·06
900	532·71	5½	952·85	20	1269·45
920	535·33	5¾	962·31	25	1334
940	537·89	6	971·45	30	1389·15
950	539·16	6¼	980·30 (8)	50	1556·14
960	540·41	6½	988·88	100	1815·28

(1) Bismuth melts, 471·6°. (Dixon on heat.)
(2) Leads melts, 576°.
(3) Iron, read heat in the dark, 635°.
(4) Linseed oil boils, 640°.
(5) Mercury boils, 662°.
(6) Charcoal burns, 802°.
(7) Antimony melts, 810°.
(8) Iron, dull red heat, 980°.
(9) Heat of a common fire, 1141°.

The following are the several melting heats of some of the more refractory metals, witb the pressures of steam of equal temperatures calculated by the formula:—

Calculations of Pressure in Tons per square inch.		
114	Brass melts at	1869° (11) Fahr.
115	Silver "	1873° (12) "
153	Copper "	1996° (13) "
237	Gold "	2200° (14) "
326		2360° (15) "
687	Cast iron "	2786° (16) "
959	Subterranean fusion ...	3000° (17) "

Tbe temperatures marked [6], [8], [9], [10], [11], [12], [13], [14], [16], are on the authority of Professor Daniell, F.R.S. [15], the temperature 2360°, is stated by Dr. Macquorn Rankine, F.R.S., to be that about at wbich the water in an engine boiler would be totally evaporated. (ARTIZAN, Nov., 1863, p. 252.) [17] In Sir W. G. Armstrong's address to the British Association, at Newcastle (p. 9), he assumes the temperature of subterranean fusion to be 3000° Fahr. The other melting points, &c., have been obtained from a small volume on steam, published by tbe late Mr. Weale.

Earthquakes, Volcanic Explosions, and Upheavals of Strata.—There is another point of view in which this formula may possibly be not witbout interest to a class of scientific men, other tban engineers. More than a century ago the Rev. John Michell, M.A., "conjectured" that steam might be the cause of earthquakes, and he reasons very ably at considerable length on the subject.* His idea, however, seems to have been dropped, except by a very few, by whom it is entertained only as one out of several conjectural causes. Now if, as must now and theu happen, fissures open in the bed of the sea, by tbe action of earthquakes and close again after a few seconds or minutes, it follows that a large body of water will rush down and be imprisoned, and come in contact with the fused matter below. This water will necessarily be converted into steam, which will only remaiu quiescent as long as it is everywhere surrounded by a resistance greater than its own expansive force. If the formula approximates towards the truth, unless the resistance amounts to a thousand tons per square inch or thereabouts on every side, in certain cases an explosion will take place of sufficient force to account for an earthquake or volcanic eruption, as the case may be. In reading accounts of volcanos and eartbquakes, it will frequently be observed that *hot water* aud *steam* are ejected, to say nothing of the *hot water* aud *steam* which uotoriously issue from boiling springs and geysers. Tbe writer has made a considerable collection of such cases. There is then plenty of direct proof of the existence of steam in the bowels of the earth, and steam will not be idle if it can find any point of less resistance than its own expansive force. Therefore, in considering the cause or causes of earthquakes, volcanic explosions, and upheavals of strata, you cannot get rid of steam. For let us look from whatever point of view we will, the pressure of saturated steam must be enormous long before it reaches the temperature of 3,000 degrees.

NEW CURRENCY AND MINT AT HONG KONG.

The *London Gazette* has recently announced the appointment of a Master of her Majesty's Mint at Hong Kong, and we have reasou to believe that the machinery and appliances for such an establishment are in course of preparation in this country. This step has been taken at the immediate instance of Sir Hercules Robinson, tbe present Governor of the colony, altbough to Sir John Bowring, his predecessor in that office, belongs the credit of first pointing out the anomalous condition of the currency there, and the necessity for its total revision. So long back as the year 1854 Sir John wrote of the annoyances which were felt in the British Colonies in general, and in that of Hong Kong in particular, from the arbitrary system existing there, of keeping all tbe public accounts in pounds, shillings, and pence. "No matter," he said, "iu what coins or currency the transactions of commerce really take place—no matter what may be the usages of merchants or the habits of the people—in utter disregard to the loss of revenue, to tbe difficulties of adjusting contracts, and to the innumerable inconveniences which are inseparable from two systems of accountancy in the same locality, English coins and English denominations have been adopted for all receipts and payments in the public departments. In countries where the pound sterling is unknown to commercial bookkeeping, and wbere its value is subject to perpetual fluctuations, an unchangeable value has been affixed to it by Royal Proclamatiou. . . . . In Hong Kong, for example, ber Majesty's Orders in Council have proclaimed that a Spanish pillar dollar and a dollar of Mexico shall have the same current value—in the face of a notorious fact that the Spanish dollar is habitually received at a premium of from 2 to 10 per cent. above the Mexican. A sovereign is ordered to pass for 4 dollars and 80 cents, though it sometimes will not produce (gold not being current in China) within 8 to 10 per cent. of that value, and in the ports of China has been known to be at a discount of 20 per cent. The fluctuations of exchange are a necessary result of the fluctuations of supply and demand, and can no more be controlled by laws or ordinances than can tbe flux or reflux of the tides. . . . . The Order in Council now in operatiou directs that tbe public accounts shall be kept in sterling money, but that all money contracts may be legally kept in gold Mohurs at the rate of 29*s.* 2*d.*; in tbe dollars of Spain, Mexico, and South America at 4*s.* 2*d.*; in rupees at the rate of 2*s.*; and that the currency of England shall circulate at its current value. But as tbe monetary transactions of Hong Kong are small, and those of the adjaceut contiuent of China enormous, all the accounts except those of public functionaries are kept in Spanish dollars alone."

Such was the testimony of Sir Johu Bowring so long back as the year named, and at a time when practical experience—that stern and truthful teacher—had enabled bim to speak with all the weight of its authority. Tbe justification urged on behalf of tbe system thus sanctioned by Royal Authority, was that such assimilation of value in coins of the same intrinsic worth would lead to the removal of prejudices from the Cbinese mind in favour of a particular coin. Tbe results, however, have proved the utter impotence of such legislation, as the difference between the exchangeable value of the dollars of Spain and America has never been so great as since the existence of the Order in Council, which declared their values to be equal! and the inconveniences to which the former Governor of Hong Kong so strongly adverted have not grown less since that able man returned to this country; and Sir Hercules Robinson—his scarcely less able successor—has not failed to impress the fact upon the Secretary of State for the Colonies, and, through him, upon the Home Government. Accordingly, we find Sir Hercules writing (March 9th, 1861) to the Duke of Newcastle, in the course of an exhaustive despatch on the whole subject, as follows:— "Aud here I may observe on the manner in which the Colonial Government accounts are at present kept, that nothing could well be more inconvenient and complicated. The revenue, as has been observed, is almost all paid in dollars, but it is brought to account in terms of sterling money. The estimates and appropriation ordinauces are made out in sterling, but the contracts for the supplies and public works are all made in dollars, and the wbole expenditure is paid from the Treasury in dollars, while it is charged in the accounts in pounds, shillings, and pence. I am not aware of any one advantage that is gained by all this trouble and confusion, and, therefore, I recommend that permission be given to keep the accounts of the local government in dollars and cents in the same way as the accounts of any foreign banking and mercantile establishment are kept. I find that both the Executive and Legislative Councils of the Colony have already unanimously recommended this change." Sir Hercules next proceeds to detail other vexatious consequences which ensue from the constant conflict between dollars and cents, pounds, shillings, and pence, and the existence in large quantities of Chinese cash among the native population of Hong Kong. Upon this latter coin, the cash or "tsien," his remarks are sufficiently curious aud interesting to justify quotation. "The cash," he says, "is tbe only coin issued by the Chinese Governmeut, and it is made from a compound or alloy of copper, iron, and 'tutenague.' It is circular, nine-tenths of an inch in diameter, and has a square hole in the centre, by which pieces are strung iu parcels of a hundred, for the convenience of counting, as also of carrying. It is cast, and not stamped or minted. The obverse bears the name of the province in which it is cast, in Manchu writing on the right side of the square hole, and tbe Manchu word for money on the left. On the reverse are four Chinese characters; those above and below the hole giving the Emperor's name

* Phil. Trans. R.S. 1760. Vol. II, p. 447, &c.

(as Táu Kwang, Hien fung, &c.), and the words 'tung pau,' signifying current money, on the left and right of it. The weight of each piece should be 57·98 grains, or one mace (tsien), and hence it is called by the same name, but modern pieces weigh from 62 to 64 grains each. The value of the coin as fixed by the Government is the thousandth part of a tael's weight of silver, at which rate about 700 would be equal to a dollar; but, through the rapacity of provincial governors (there being mints in most provinces), or the frauds of the workmen employed, the coin has been for many years debased in the coarsest manner with iron-dust and sand, and the price of it in the Canton market at present is about 1,358 cash for a tael, or 970 for the Mexican dollar. . . . This value is fixed daily by the money brokers, who meet in conclave and determine the price, which, as I far as I can learn, appears to fluctuate above the intrinsic value of the coin according to the supply of it in the market."

By the existing proclamation, Chinese cash are made a legal tender to the extent of one shilling sterling, at the rate of 1,200 for one dollar; but as 970 coins of the present depreciated Government cash are equal to one dollar, the Royal Proclamation in this respect, as in all others, has been a nullity. Until very lately, however, a number fully equal to that specified in the proclamation has passed in the colony for a dollar, in consequence of the large quantity of spurious cash which has been in circulation throughout China for years, notwithstanding the strong measures taken by the Government to suppress the illicit manufacture of it by awarding death as the punishment for forging.

When it is known that in addition to the difficulties arising from the complex system of account-keeping, and the intermingling of British and Chinese coins, mentioned by the Governor and ex-Governor of Hong Kong, that there are in circulation in that colony, also, innumerable specimens of the mintages of other nations, the troubles of its inhabitants will be yet more clearly understood. It is no wonder, therefore, that attempts should be made by the authorities of the colony to overcome them, or that those attempts should be seconded, supported, and at length legally authorised by the Imperial Government. The first step actually taken towards this end, was the authorisation of a new coinage for Hong Kong, to be struck at the Royal Mint in London, and composed of ten cent. pieces of silver, each representing the tenth part of a dollar; one cent. pieces of bronze, each of the value of *one* hundredth part of a dollar; and cash or mil pieces of the latter metal, perforated in the centre by a round hole for stringing, and each of the recognised value of one thousandth of a dollar. Instalments of these have, during the present year, been coined at Tower-hill, and forwarded to their destination. New designs, of course, had to be prepared for the whole, and these were drawn and engraved by the present acting engraver of H.M.'s Mint, Mr. T. J. Minton, The silver ten cent. piece has, for its obverse, the head of the Queen, a *fac simile* (of course much diminished) of that which ornaments the English florin, surrounded by the legend, "Victoria, Queen." The reverse comprises a wreath, and the inscription, "Hong Kong, 10 cents. 1863," with Chinese characters to the same purport. It is a neat and well-proportioned coin, and the edge is serrated or milled. The one cent. piece has a similar obverse and reverse, and its size is rather larger than that of the British halfpenny. The bronze cash or mil is a very peculiar sample of minting. Its diminutive size, and small value—the twentieth part of a penny—with its central perforation, making it, indeed, a perfect curiosity. It was found to be next to an impossibility, mechanically speaking, to coin these remarkable pieces with square holes through them, in imitation of the Chinese cash, which are all cast in moulds. A compromise was, therefore, effected by the introduction of round holes, with square bands surrounding them. As these holes were punched before the pieces were struck between the dies, and while they were in the form of planchets, it will be readily comprehended that much care had to be exercised while striking them, in order to prevent distortion of the perforations. One million of the cash pieces were coined at the Mint, and the remaining portion, nineteen millions, at Messrs. Heaton's, Birmingham. The obverse device upon the cash, or as it is preferred to name it—the mil—consisted of a crown on the upper side of the square band, and below the band the inscription, "1 mil, Hong Kong, 1863." The reverse was formed simply of Chinese characters, conveying the same meaning, for the benefit of the native population of the colony.

As has been stated, the first portions of this coinage have been sent to Hong Kong, and are, probably, at this moment, in the hands or round the necks of some of the 120,000 Chinese who assist in peopling it.

Of ten cent pieces there were despatched 100,000, equal in denominational and intrinsic value to 1,000 dollars of the United States; of one cent pieces 1,000,000, equal to 10,000 dollars; and of the cash or mil coins, 20,000,000, representing nominally 20,000 dollars, reckoned at the rate of 4*s.* 2*d.* each. It is more than likely that this new coinage will find favour with Eastern Asiatics beyond the limits of the colony to which it has been shipped, and there can be no doubt that it will largely facilitate the extensive traffic now going on along the adjacent coasts. The probability is, therefore, that the quantity sent will soon be absorbed, and that a very much larger supply will be required. In order to make this purely decimal system complete and perfect, it will be necessary to institute eventually a dollar coinage, and in such case the Mexican and Spanish coins of that denomination will be driven from the field.

In view of these circumstances, and regarding probable future contingencies, the British Government have determined to establish a mint at Cowloong, one of the healthiest sites in Hong Kong. Capt. Kinder has been gazetted as master of the new money manufactory, and, with a staff of assistants, that gentleman is actively engaged at present in superintending the designing and construction of the engines, machinery, and fitments necessary for carrying on the work. It cannot be expected that all the arrangements will be completed in less than a year or more; and so peculiar a colony is Hong Kong, so helpless is it as regard the processes of manufacturing industry, that it will be incumbent upon those who are to have the control of the mint to foresee its every possible requirement in the shape of material, and to provide for it before leaving England.

Of course the newly-appointed official will have all the advantage of an initiatory education, as it were, in the art of coining, as practised at the Royal Mint, before departing for the scene of his future arduous labours, and this he will find of great value unquestionably. The introduction of a new currency into Hong Kong is, after all, an experiment, but so well judged do the preliminary steps taken appear to be, that there is small room for fearing its non-success. The advice and co-operation of the members of the Chamber of Commerce of the colony have been secured by Sir Hercules Robinson, and these, in conjunction with his own aptitude and tact, are almost certain to effect the desideratum—the introduction of a uniform and simple currency at Hong Kong, popular alike with the British and Chinese residents. Once this shall be effected, and the mint put into successful action for its perpetuation, there is no saying what contagion may not do for the Celestial Empire itself. The Chinese are naturally observant and quick witted, and when they become aware of the wondrous ease with which large quantities of the circulating medium is produced by stamping presses in a neighbouring island, they may be disposed to desire similar advantages for the great continent over which the Brother of the Sun wields his sceptre. It would not be the first time that the celestial people had copied the plans of us poor terrestials, especially when they were found to be pecuniarily profitable. It is extraordinary, indeed, that, so far as coining is concerned, the Chinese nation are not further advanced than were the inhabitants of these islands in the time of the Heptarchy; and that they actually manufacture their national cash in the same manner that the counterfeit coiners of England, at this moment, produce spurious florins and half-crowns.

The future of China is indeed one of the problems of the present time. We foresee that eventually that vast country will be opened up to the introduction of English machinery, and believe that ere many years shall have passed away, the whistle of the locomotive will be heard by his Celestial Majesty at Pekin!

PROPOSED TUNNEL UNDER THE RIVER MERSEY.

A Paper read before the Liverpool Polytechnic Society.

By Mr. T. J. Edwardes.

The subject of improving the transit across the River Mersey is one of deep importance to the prosperity of Liverpool and Birkenhead, and is now becoming a serious matter—much more serious it is to be feared than is generally imagined; but the Liverpool Corporation and the Mersey Docks and Harbour Board have, up to the present time, shelved the subject of improving the approaches to the river, owing, doubtless, to the utter inadequacy of the plans hitherto proposed for the accomplishment of the object in view, and to the pecuniary difficulties that would have to be overcome. Bearing all these things in mind, viz., the apathy that has so long prevailed among the public bodies in this town respecting the improvement of the approaches to the river, and the establishment of steam-bridges, it is clear that the excavation of a tunnel (such as is shown in the accompanying plan and section) under the bed of the river, is the only mode of effectually connecting together the two towns as one place for the purposes of trade and commerce.

The necessity which exists for a better mode of communication between Liverpool and Birkenhead is self-evident to those who have to cross the river. The inconveniences of detention arising from the fogs which prevail so constantly in the winter months, added to the inclemencies of the weather, are not the only reasons why another system of communication should be opened up. Collisions are of frequent occurrence, and so alarming has this condition of things become, that of late years the residents on both sides of the river have memorialised the Dock Board on the matter, with the view of obtaining an exercise of their authority as the Conservators of the Mersey, to prevent the anchoring of vessels in the fairway of the ferry steamers, and thus afford a greater chance of perserving lives from the disasters to which river passengers are under the present system unhappily exposed. This memorial on its presentation aroused the Board to the great importance of the matter, and instructions were given with the view of remedying the grievance. Unfortunately, however, the difficulties are greater than were anticipated, and up to the present time no effectual remedy has been provided. The daily increasing strength of the mercantile marine, and the wonderfully augmenting prosperity of the port, must necessarily increase the difficulty, and render its entire removal a question of the greatest possible doubt.

Now, more than thirty years ago scientific men of reputation and fame had in view the desirability of forming a tunnel to connect Liverpool and Birkenhead. What, therefore, must be the urgency now, when the population on the Cheshire side numbers 60,000 individuals, requiring safe and expeditious conveyances to Liverpool in all weathers ?

Doubtless there are those who say that the ferry communication is improving day by day, but even these advocates for the ferry must have been convinced, during the late autumnal storms, of the impossibility of devising any plan for a ferry boat to satisfactorily conduct the ordinary traffic in boisterous weather. Now, by means of the proposed tunnel, residents on the Cheshire coast would be landed, in a few minutes, in the centre of Liverpool, without any such inconvenience and exposure as results from travelling by steamers. But the greatest necessity for a tunnel has yet to be considered, viz., the development of the splendid and unsurpassed docks at Birkenhead, upon which so much money has been expended.

Those who ought to know better, will tell us that steam boats, specially adapted to carry laden carts with their horses intact, will be constructed for ferrying across the immense traffic of such a dock as the great float. Is this possible ? Bearing upon this subject, we may here refer to an extract from a speech that was lately delivered at a meeting of the Mersey Docks and Harbour Board, by one of the members, who said, "He had no interest to serve in Liverpool more than in Birkenhead. He wanted to see this a cheap and effective port; but were there gentlemen who would consider the transit across the Mersey, with such tides and such storms as we have here, and think of moving the contents of warehouses on this side, for exportation across the water in lighters or steam bridges ? He might be very ignorant in the matter, but he had seen what had been done at Portsmouth, he knew perfectly well what had been done at New York, and he knew of no port where there was a tidal river like this, and subject to a fall, where steam bridges ever had been brought into operation."

Let us turn, however, to the local trade. The shopkeepers of Birkenhead and neighbouring townships, have much difficulty in getting their goods across, and the Telegraphic Companies likewise have difficulties in conveying their messages ; they even propose to erect two tall towers of great height on each side of the river, to support the wire.

Now, by means of the tunnel proposed, passengers from Chester, and all places reached by railways bifurcating from Chester, would be saved the annoyances and risk of crossing to Monks Ferry by boats, having only to get into the train at Whitechapel Station to proceed comfortably to their several destinations. The Birkenhead Park would be, as if by the wand of the enchanter, brought to the centre of the town, and the ratepayers of Liverpool would reap unparalleled advantages and many enjoyments without payment, and would be spared from having to contribute by rate (which would be a considerable tax) to the improvement of the river approaches.

We now come to the description of the proposed tunnel, its practicability and cost. It is, however, here to be understood that the author of this paper claims no originality in suggesting the formation of a tunnel under the Mersey, being well aware, as before stated, that several suggestions have been made for effecting the same object; with this difference, however, that all previous schemes had no locality assigned to them, and have had the fatal defect of the Thames Tunnel—requiring either winding stairs, or steam hoists to get up and down. The originality in the present scheme, consists in the idea of forming a tunnel from the corner of Conway and Camden Streets, in Birkenhead, to the corner of Preston-street and Whitechapel, in Liverpool, with descending inclines from each end to the centre of the river, of about one in forty. The traffic to be carried on railways, worked by locomotives, thereby welding the broken link in the chain of railway communication between Lancashire and Cheshire.

It will be seen by referring to the accompanying plan, that it is proposed to commence on the Cheshire side at the low plot of vacant land having Camden-street on the west side and Conway-street on the south side—Conway-street, at this point, being only 26ft. above the level of the Old Dock Sill, and 700 yards from the main entrance to the Birkenhad Park. As far as the intersecting point with the Birkenhead Goods Railway there would be an open cutting; underneath the former it then passes, and proceeds, as shown on the plan, to the north of the Woodside landing stage, under the river, and to the south of George's baths, continuing under Derby-square, and emerging on this side of the river at the site of the American Circus, and other buildings, having Shawhill-street on the north, Preston-street on the east, and Whitechapel on the south side—Whitechapel being at this point 28ft. above the Old Dock Sill, 550 yards distant from the Town Hall (from the landing stage to the Town-hall being an equal distance), 500 yards from the Exchange Station, 310 yards from the Lime-street Station, and 420 yards from the proposed Central Station in the Arcade. The curved lines show its ramification with the London and North-Western Railway on the Liverpool side, and with the Birkenhead Railway on the other side. The total length of the tunnel would be 1 mile, 7 furlongs, and 100 yards, or 3,400 yards.

With reference to the nature of the ground of the proposed site for the tunnel, the Admiralty chart shows rock in the centre of the river, and there are substantial proofs to show that from Market-street on the Birkenhead side, to Sir Thomas's-buildings on the Liverpool side the of river, would be entirely in the red sand stone. From Sir Thomas's-buildings would be an open cutting having 3ft. to 5ft. of rubbish, and 8ft. to 12ft. of clay on the top of the reck. The information upon this subject has been derived from a gentleman who has had much to do with the sewerage works of Liverpool.

The Ordnance Geological Map also shows the stratum through which the tunnel would pass to be most favourable for such an undertaking.

The method of proceeding with the excavation of the intended tunnel would be the sinking of the working shafts to admit readily of lowering men and materials, raising the materials excavated, fixing pumps, and also starting the headings of the intended tunnel when the required depth is reached; three of these working shafts to be sunk on each side of the river, the ventilating shaft on each pier head to be sixty feet in diameter. The steam engines would be set up at the shafts for the purpose of freeing the tunnel of water during the progress of the works, and after completion a small permanent engine would be fixed at one of these large shafts for pumping up any water that might percolate through the brick lining, and also (if it should be found necessary) working machinery to assist in the ventilation of the centre portion of the tunnel. The other working shafts to be 9ft. in diameter. Besides the working shafts, air-shafts 3ft. in diameter would be sunk for the purpose of ventilating the works below.

The greatest length of the tunnel that would have to be excavated from a single face is 620 yards. By carrying on the works with shifts of men, one yard advance could be made in every twenty-four hours, at which rate the tunnel would be completed in two years.

That portion of the tunnel under the bed of the river, and to such a distance on each side of the river as should be found necessary during the progress of the works, would be lined with brickwork set in cement, and well puddled at the back to keep out the water that would enter the excavation through the fissures in the rock—the brickwork of the side walls to be eight half bricks in thickness, the arch seven, and the invert six—observing that the brickwork should be immediately executed all round, reducing the unprotected or uncased portion to a minimum, and thus the security of the work would be ensured.

The arrangement for the pumps would be the sinking of a well of small diameter, lined with brick-work, to a depth of about 20ft. immediately underneath the two 60ft. shafts, the level of the tunnel would be at these points about 45ft. above its centre; from thence narrow guts could be cut under the invert down the centre, to a tank at the lowest part of the tunnel, in which the suction pipes could be laid almost horizontal to the pump barrels, worked by direct action from the surface.

The Kilsby Tunnel (one of Stephenson's great works), on the London and North-Western line, is 2,423 yards long; its length is divided by two shafts 60ft. in diameter; quick-sand extended over 450 yards of its length, and the pumps brought up nearly 2,000 gallons of water per minute, and it is one of the most expensive railway tunnels constructed in the kingdom, having cost £130 per lineal yard; the Box Tunnel, on the Great-Western Railway, cost £100 per lineal yard; the Bletchingly Tunnel, on the South-Western Railway, cost £72 per lineal yard; and the Salswood Tunnel, on the same line, cost £118 per lineal yard.

"In the early ages of engineering experience (quoting from the *Quarterly Review*), tunnels seemed far more formidable undertakings than bridges. Men could face what they saw, and undertake what they could calculate; but it was another thing to burrow into the bowels of the earth to encounter rocks or quicksands, or it might be springs and moving clays, and all this in darkness and in ignorance of what might come next. All these things are now becoming perfectly understood, and the mode of making them settled. There have, in fact, been more than eighty miles of tunnels excavated for railways in the kingdom, done under every variety of circumstances and difficulty, and at an average cost of only £45 per yard forward. The experience so gained has been such that, were it now proposed to execute a new tunnel under the Thames, there are twenty contractors who would be ready to undertake it and carry it through. The first, indeed, would hardly have been found so difficult of execution had it not been carried too near the bottom of the river, where the soil was only recent sediment and rubbish.

"We have become so familiar with these wonders, that it is curious to look back on the interest and excitement caused by an attempt to carry a roadway under the Thames, and still more, to turn to what occurred less than one hundred years ago, and mark the incredulity and the ridicule which were displayed when Brindley proposed to cut the Harecastle Tunnel in Staffordshire.

"Compare this with the great tunnel under Mount Cenis, nearly five times its length (40,000ft. long, and is estimated to cost £150 per yard forward), and at a depth of a mile below the summit, so that shafts being impossible, it has to be worked wholly from the ends, and so far as can be ascertained, through hard rock the whole way. But the remarkable fact is, that no one seems to doubt the success of the undertaking, and any one attempting to ridicule its projectors, would only render himself ridiculous."

We have cited the preceding remarks for the purpose of showing the cost of some of the great tunnels constructed and in course of construction; but before venturing upon a statement of the probable cost of excavating the proposed tunnel under the river Mersey, it may be mentioned that the author of this paper has been engaged on various engineering works, railways, works of irrigation, and extensive bridges, and therefore, from his own experience, and from valuable information that has been furnished to him by a gentleman well able to arrive at a correct estimate of the cost of excavating tunnels in the red sand stone, the author has come to the conclusion that £400,000 would leave a handsome margin after the formation of the tunnel—viz., £75 per lineal yard for the shore portions, and £175 per lineal yard for the river portion.

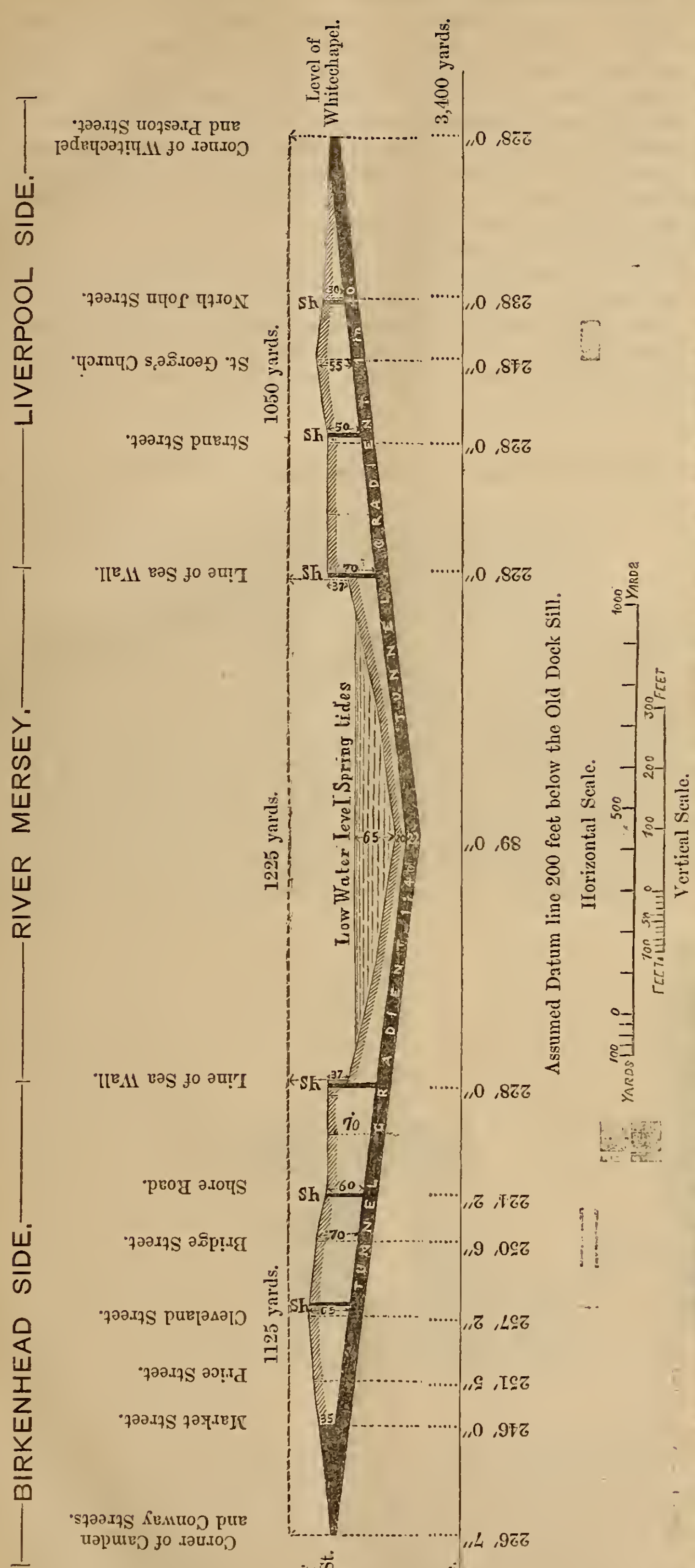
Then as to the working of the traffic. The Lickey Incline on the Birmingham and Gloucester line ascends at 1 in 37 for a length of 3,600 yards, from Broomsgrove Station. On the Edinburgh and Glasgow Railway is an incline of 2,968 yards in length, of 1 in 43—both of which are worked by locomotives. On the Oldham and Manchester line the locomotive can be seen dragging very heavy trains up an incline of 1 in 27. The Bhôre Ghaut incline on the Great Indian Peninsula Railway is 15¾ miles in length, and the total ascent is 1,831 feet, averaging 1 in 48; but for one mile and a half it is 1 in 37, and for eight miles it is 1 in 40, and is worked with facility by the locomotive.*

The length of the two descending planes in the projected tunnel would be 1,700 yards, at about 1 in 40. The trains worked by locomotives would produce in descending and ascending a compensating effect, and a variation of speed in the train would be the whole amount of inconvenience that would ensue—the time of performing the journey would be the same as on a level line.

Now let us consider that which is of primary moment to the future success of the scheme as a financial operation. The amount of dividend likely to be afforded for the capital invested in the undertaking, though of essential import in the first instance—inasmuch as without the prospect of realising at least a paying dividend, the Mersey Tunnel will not be constructed at all—is, nevertheless, to be regarded as a subordinate consideration, when compared with the vast and important collateral advantages which the establishment of the tunnel would in other respects confer on Liverpool and Birkenhead; but it is a question demanding the serious consideration of the Liverpool Corporation and the Mersey Docks and Harbour Board, whether it would not be politic for these public bodies jointly to guarantee a minimum interest of three per cent. on £400,000 from the opening of the tunnel, and it is a further question whether it would not be for the interest of the several railway companies having their termini in Liverpool and Birkenhead, to become large subscribers to the undertaking; however, from the following particulars it will be seen that the scheme contains in itself the germ of a noble dividend. The Woodside Ferry boats conveyed across the river in the year 1862, seven millions of passengers, and realised £29,000; the Wallasey Ferry steamers realise from £18,000 to £20,000 a-year. The majority of the passengers from Poolton, westward by Wallasey village, Bidston, Hoylake, and around by Pargate, Weston, Bebington, and Tramere, would converge to

* An account of this important engineering work will be found in the Artizan, Vol. for 1863, p. 141; and a Plate and description of the Locomotives employed for working the traffic, in the Artizan, Vol. for 1862, Plate 224, p. 219.

SECTION AND PLAN OF PROPOSED TUNNEL UNDER THE RIVER MERSEY



the tunnel station in Conway-street to reach Liverpool; and in stormy and foggy weather, the whole of the population of Cheshire would cross, *viâ* the tunnel. The passeuger and goods traffic of the Birkenhead and Chester Railway, which are now centered at Monks Ferry and Canning-street—the existing goods traffic carried over by the several ferry steamers —the transit trade that has to be developed appertaining to the Birkenhead Docks—the trains with the steam coals from South Wales—the traffic to be created by the Birkenhead, Hoylake, and Flint Railway—and lastly, the privilege to the Telegraph Companies of laying their wires along the tunnel—would be a traffic, a fraction of which, if it came by the tunnel (as no doubt it would), would pay a dividend equal, if not superior, to the best paying railway in the kingdom. Experience has shown that the introduction of railways into localities previously without this improved mode of conveyance, has generally caused a manifold increase of traffic; the lowest of the usual result being to double that which previously existed. Whether such a result may be expected in the present case, is left to the judgment of the intelligent public.

We have thus briefly described and explained the project for constructing a tunnel under the bed of the Mersey; the experience of the past confirms the calculations, and encourages the hopes of the present, while every well-wisher of the towns on either side of the river should hail a more desirable mode of communication between them as essentially important to the interests of both. A tunnel under the Mersey will most assuredly form a link in the records of future engineering and commercial enterprise, and probably not many years of the present generation will pass away before this important work is executed.

[From the earliest days of the establishment of docks on the Cheshire side of the Mersey, we have taken great interest in that undertaking (*vide* the ARTIZAN of May 1st, 1847), and believing that the proposed tunnel will be an indispensable adjunct to their financial success, it has given us great pleasure to find room for the above paper, and, we may add, that we wish the proposed scheme every possible success.—ED. ARTIZAN.]

INSTITUTION OF MECHANICAL ENGINEERS.

DESCRIPTION OF A HYDRAULIC SHEARS AND PUNCH.

BY MR. JAMES TANGYE, OF BIRMINGHAM.

The object of this hydraulic shears is to afford the means of readily cutting large sections of bar iron or railway rails, with the power of one man only, and with a machine of simple and compact construction.

This shears is shown in the accompanying wood cuts, Figs. 1 and 2, and consists of a strong vertical cast iron frame A A, divided in the centre horizontally, in the upper half of which the upper shear blade B is fixed; and a short hydraulic press C is cast in the lower half of the frame, having the lower shear blade D fixed upon the top of the ram of the press, which is 10in. diameter with 3in. length of stroke. The upper and lower castings of the frame are secured together by two bolts E E, 3in. diameter. The box F bolted upon the side of the cylinder contains the force pump G, and serves as the reservoir for the water of the pump. The pump consists of a single brass casting, and is screwed into its place in the side of the hydraulic press, and contains a small conical suction valve and delivery valve, $\frac{1}{4}$in. diameter, held down to their seats by spiral springs. A small wire gauze guard is fixed over the outside of the inlet and outlet openings of the pump, to prevent any dirt from getting into the press cylinder. The plunger, $\frac{3}{4}$in. diameter and $1\frac{1}{2}$in. stroke, is continued backwards to work in a guide socket in the end of the reservoir, and a tongue on the shaft of the hand lever works in a square slot in the plunger rod.

The shear blade D is lowered after the cut by means of a self-acting motion connected with the force pump lever. The length of stroke of the lever is limited in ordinary working by a stop pin fixed on the side of the cistern, which catches the lever at the bottom of its stroke; but by shifting the lever $\frac{3}{8}$in. outwards upon the squared end of the shaft, it is made to clear this stop pin, and is pushed down into a lower position. The tongue working the plunger then advances to the position M, Fig. 2. Upon the prolonged end of the plunger reaching the delivery valve of the pump it presses it open, and allows the water to flow back from the press cylinder into the pump; and at the same time the water is allowed to flow through the centre of the plunger by a hole drilled through the entire length of the plunger. This hole is closed at the outer end by a conical escape valve opening outwards, which is kept shut in ordinary working by the tongue of the hand lever; but when the lever is depressed below the stop for lowering the shears, a recess in the tongue is brought over the head of the escape valve, allowing the valve to be forced back from its seat by the water pressure, and leaving a passage open for the water to escape through the hole in the plunger, back into the cistern. The act of raising the hand lever again into its

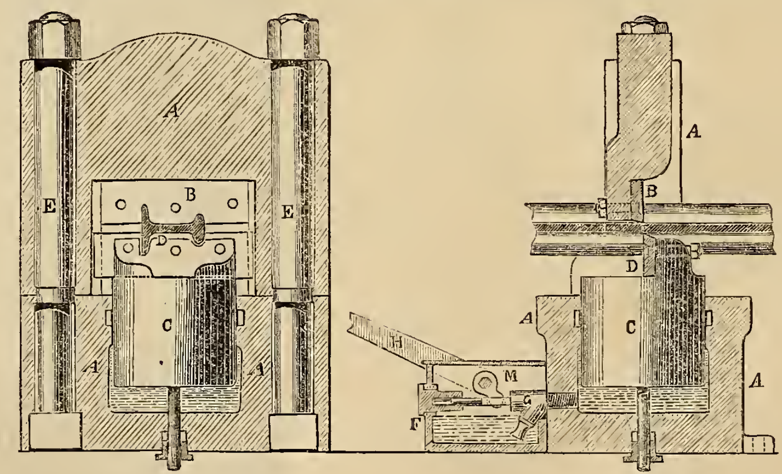


FIG. 1. FIG. 2.

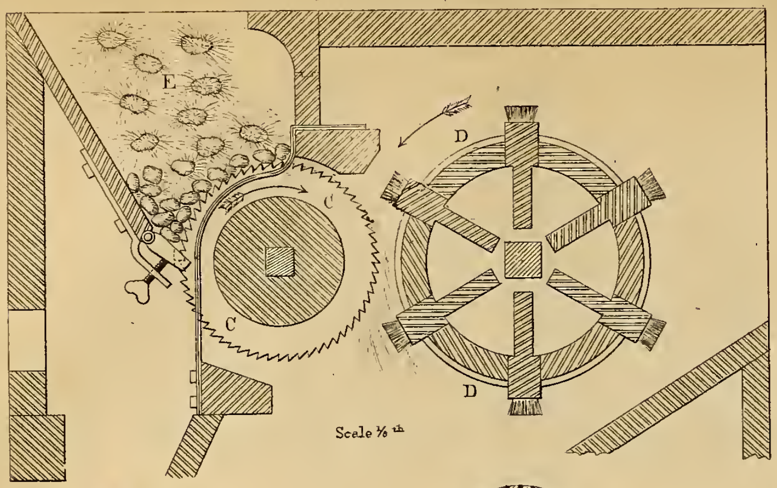
working position closes the escape valve and keeps it shut during the working of the pump. A second force pump of larger size, with 2in. diameter of ram, is used to bring up the shears quickly to the work to be cut.

With this shears a bar of wrought iron 3in. square is readily cut by one man, the time required being about $2\frac{1}{4}$ minutes. Different sizes of the shears are made for cutting bars up to $3\frac{1}{2}$in. square; the smaller sizes of bars being cut off several at a time.

This hydraulic shears is found very useful in iron warehouses for cutting large bars, where the power of only one or two men is available; and also on railways for cutting the rails, for which purpose the shears can be readily carried on an ordinary platelayer's lorry, no other foundation being required, and the whole weight being only 14 cwt. In the case of cutting rails, the shear blades are made of the same shape as the outline of the two sides of the rail, as shown in Figs. 1 and 2, so as to cut the whole section at once and make a clean square cut.

The hydraulic punch, shown in Figs. 3 and 4, is of similar construction to the shears already described, only inverted in arrangement, having the fixed die at the bottom, and the punch B fixed on the end of the inverted ram of the hydraulic press, which is 6in. diameter with 2in. length of stroke. The box containing the force pump and reservoir of water is fixed on the side of the press cylinder at the top. The punch is withdrawn quickly after the stroke by means of the spiral spring pulling up the ram; the water being allowed to escape back from the press cylinder to the cistern through the centre of the plunger by the same means as in the shears already described.

Fig. 1.



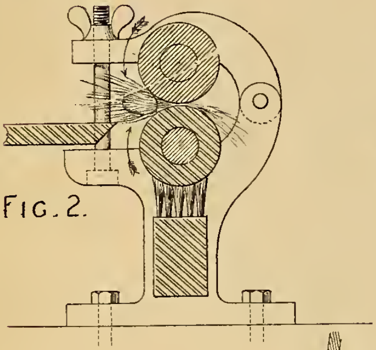


Fig. 2.

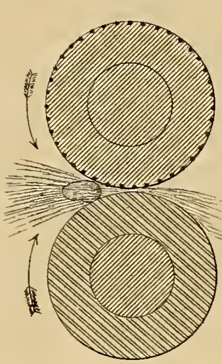


Fig. 3.

Fig. 4.

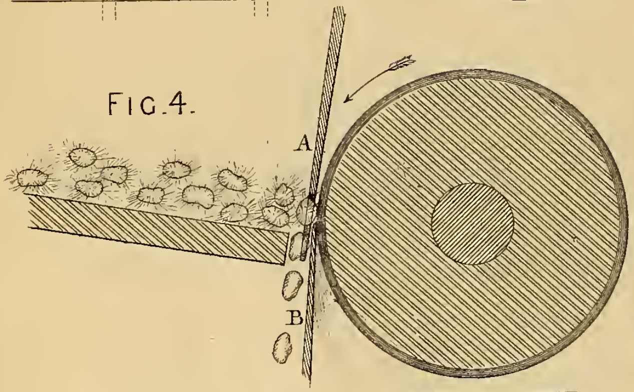


Fig. 11.

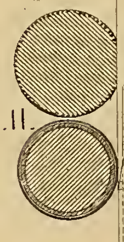


Fig. 14.

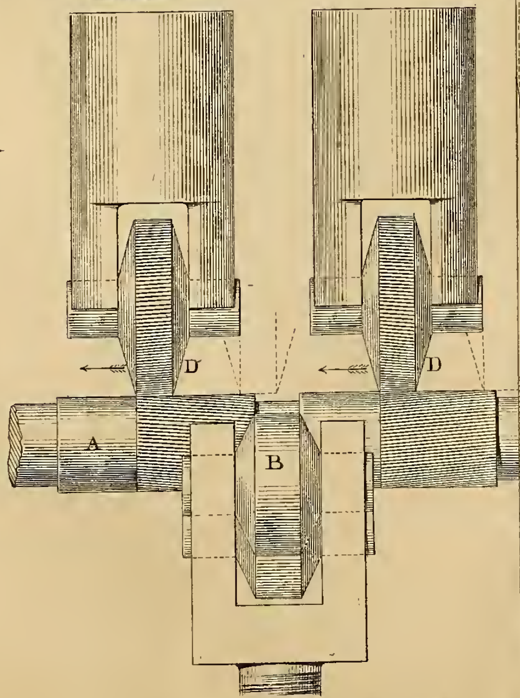


Fig. 15.

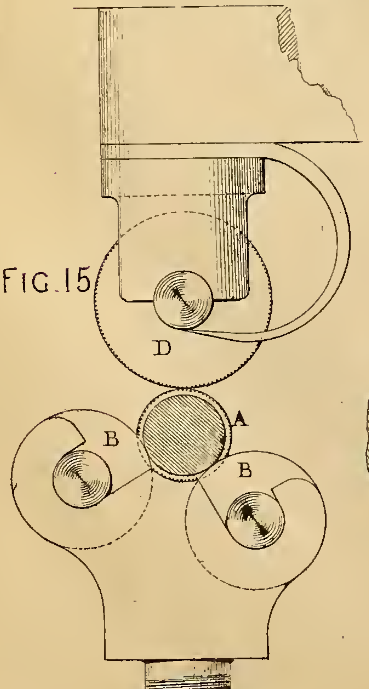


Fig. 8.

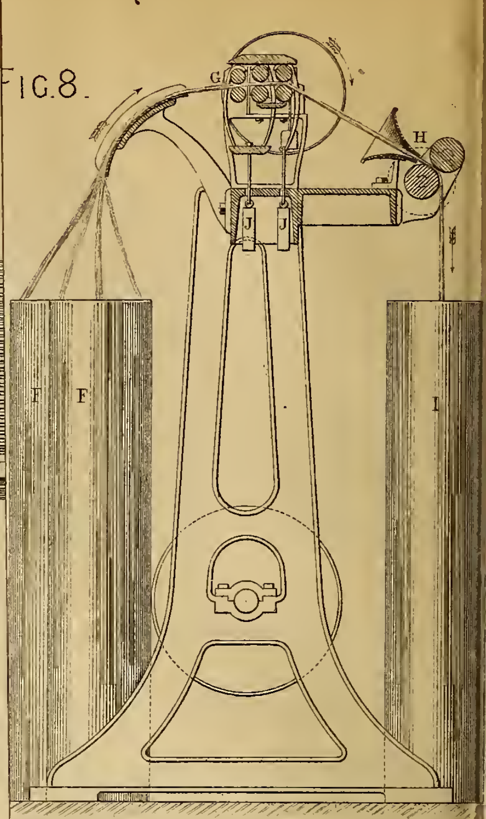


Fig. 9.

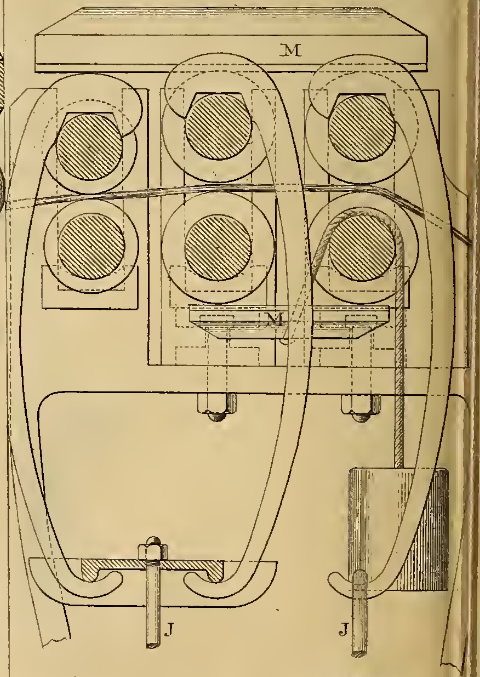
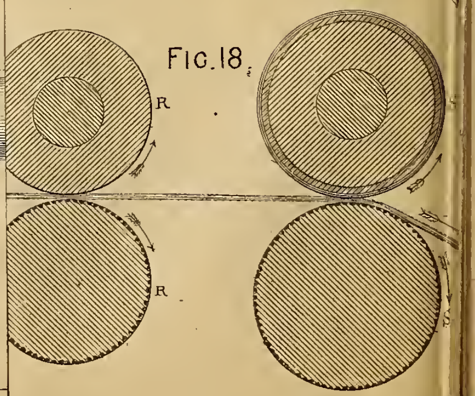


Fig. 18.



W Smith, C.E. direx.

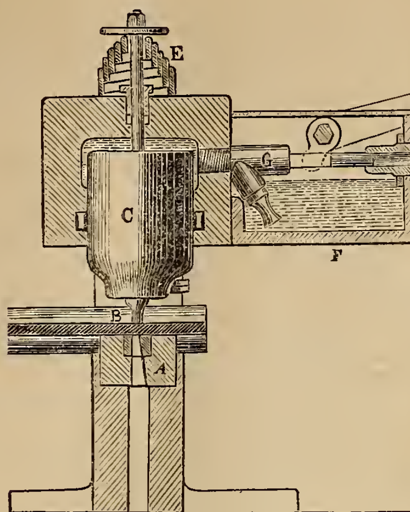


FIG. 3.

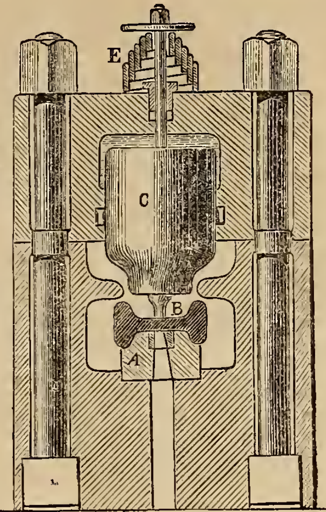


FIG 4.

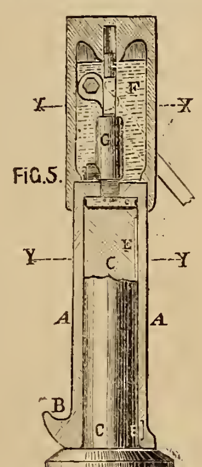
With this punch a hole 1in. diameter is punched in a $\frac{7}{8}$in. iron plate, with the power of one man in about half a minute. The machine is very portable, the total weight being only $4\frac{1}{2}$ cwt.; and it has been applied with advantage to punching the holes for fish bolts in railway rails, as shown in Figs. 3 and 4. A successful application of this machine has also been made to the manufacture of horse shoes, by punching them out cold, with the holes and countersink complete at one operation.

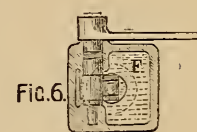
The hydraulic lifting jack, shown in Figs. 5, 6, and 7, is constructed on the same plan as the shears and punch before described, as regards the force pump. The jack consists of an inverted hydraulic press, the ram of which forms the foot upon which the jack stands, and the pump and reservoir of water are fixed on the opposite end of the press cylinder, and form the end of the jack. The ram is of wrought iron, $3\frac{1}{2}$in. diameter and 12in. length of stroke, with the foot forged upon it; and the press cylinder is formed of a hammered wrought iron bar, bored out of the solid, leaving $\frac{5}{8}$in. thickness of metal for the sides of the cylinder. A claw is forged in one side of the cylinder at the bottom, for the purpose of using the jack to lift from the bottom when required. The head forming the reservoir of water is of malleable cast iron, fixed upon the top end of the cylinder by being bored out a tight fit and pressed on up to a shoulder.

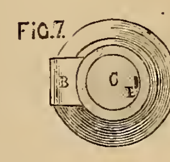
The jack is lowered by similar means to that previously described for the shears and punch; except that instead of the water escaping through the plunger, the suction valve is forced open by the same movement that presses open the delivery valve K, by means of a small inclined plane upon the prolonged end of the plunger, which passes through an eye in the stalk of the suction valve I, and draws back the valve from its seat directly after the delivery valve has been pressed open, allowing the water to flow back into the reservoir in the contrary direction to the ordinary working.

The ram of the jack is packed with a cupped leather resting in a hollow $\frac{3}{16}$in. deep turned in the top of the ram. These leathers have been found thoroughly successful in standing the pressure and wear, the same leathers having been in regular work for several years without requiring renewal. The force pump plunger in the lifting jack and also in the shears and punch is packed with a narrow strip of leather $\frac{3}{16}$in. wide, coiled round spirally in a groove turned near the bottom of the plunger, with the ends of the strip bevilled off to fill up the groove close.

The hydraulic jack shown in Figs 5, 6 is for lifting 30 tons, and several different sizes are made for weights from 4 to 60 tons. The head of the jack is prevented from turning round by a sliding block working in a longitudinal groove in the ram; but by withdrawing the screw that fixes the block the head







is allowed to turn freely with the load upon it. The hydraulic jack is convenient for use with heavy weights, from the great power obtained, one man being able to lift readily 30 tons and upwards; and from the lightness of construction, the 30 ton jack weighing only about $1\frac{1}{2}$ cwts. At the same time the loss of power from friction is comparatively small; and the small extent of wear to which the working parts are subjected gives great durability and freedom from risk of derangement.

ON THE CONSTRUCTION OF DRAWING ROLLERS FOR SPINNING MACHINERY.

(*Illustrated by Plate* 257.)

BY MR. WILLIAM WEILD, OF MANCHESTER.

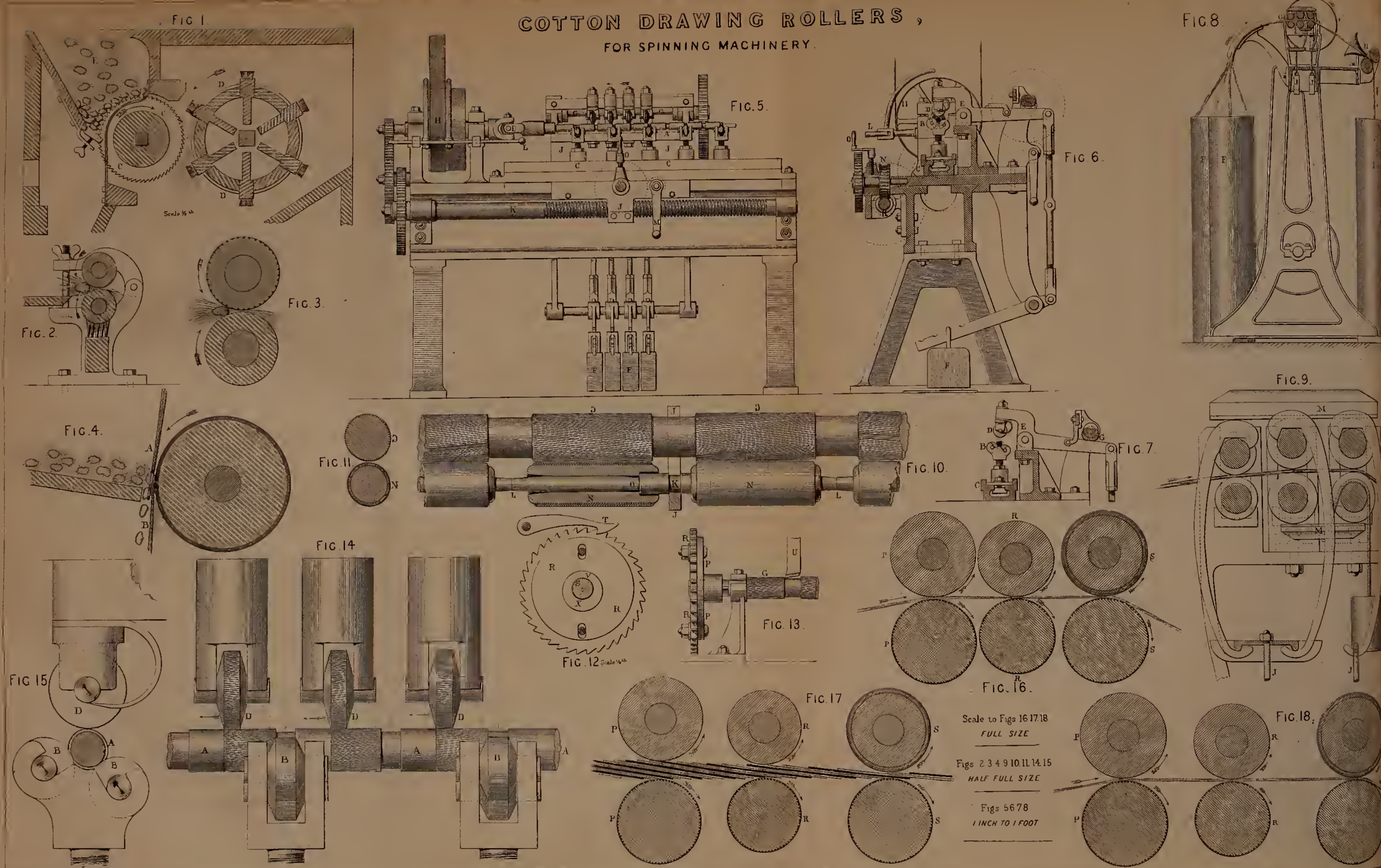
The process of laying fibres of cotton, wool, and flax in parallel and continuous juxtaposition, for the purpose of being spun into threads for various manufactures, was performed until little more than a century ago by the workman's fingers, assisted sometimes by a preliminary operation of carding, which formed the short fibres into a soft fleecy roll of about $\frac{3}{4}$in. diameter and 10in. or 12in. length according to the size of the card used. The spinning was done by the distaff, a wooden rod, round the top of which a bundle or fleece of the fibre intended to be spun was loosely wrapped. The spinner holds the distaff in the left hand, and the right hand is held about two inches below it, more or less according to the length of the fibre. A continuous lock of fibres is drawn out from the fleece on the distaff by the right hand, and the length between the two hands is twisted into a fine thread by the hanging spindle or bobbin, which is kept constantly revolving by the impulse of the fingers. The thread spun is wound up at intervals on the spindle by stopping the operation of twisting, and winding on to the spindle the length of thread already twisted; and to prevent the spun thread unwinding from the spindle whilst the next length is being twisted, it is hooked through a nick at the end of the spindle.

In 1733, Mr. Wyatt, of Lichfield, invented a machine for spinning cotton, by which, for the first time, a continuous thread was spun without the intervention of the fingers; and two factories were built and furnished with his machines—one at Birmingham and the other at Northampton. The cotton was first carded by hand and then passed between two cylinders which delivered the thread on to the bobbin while in the act of twisting. Both these undertakings failed; the machines have long since perished, and no model or detailed description of them remains. About five years later Louis Paul, of Birmingham, along with Mr. Wyatt, proposed to spin wool and cotton by a succession of rollers, cylinders, or cones, each moving proportionately faster than the preceding, to draw down the thread or sliver to any degree of fineness that might be required. The writer, however, believes he never used such an arrangement, but simply a series of pairs of delivery rollers set in a circular form but without any drawing process. In 1742, a mill was erected in Birmingham, where some of Paul's machines were set to work, driven by two asses working in a gin. He experimented for twenty years along with Mr. Wyatt, but nothing of any commercial importance ever resulted from their labours.

About 1765, two persons, named Highs and Key, experimented upon rollers

COTTON DRAWING ROLLERS,

FOR SPINNING MACHINERY.



for drawing the fibres into a continuous thread. There is no doubt but that Arkwright got some very valuable hints from them to enable him to develop the factory system. Whether Arkwright invented the drawing rollers or not, it was left for him to solve the problem how to construct a spinning machine with rollers arranged so that the first pair should draw and supply continuously a uniform sliver of parallel fibres in small portions, while a second pair should take hold of this and gradually draw out the filaments alongside of one another, and a third pair should draw the filaments out still further to the proper extent for being twisted into thread. The twisting he performed with a spindle and a fly, and the machine also wound up the thread on to a bobbin as fast as it was spun. The writer believes that Arkwright was the first to make a practical machine combining all these processes, though the question of the original invention of the drawing rollers is involved in doubt.

In 1793, Mr. Whitney, of America, invented a machine known by the name of "Whitney's saw gin," which is shown in Fig. 1, Plate 257. It consists of a wooden cylinder with a series of circular saws C. about 8in. diameter, fixed upon it at regular distances. The edges of the saws project a short distance through a grid, the divisions of which are too narrow to permit the seeds to pass through. Care is taken that the saws revolve in the middle of the grid spaces, for if they rubbed against the bars they would tear the cotton filaments to pieces. A cylinder with brushes D, the tips of which touch the saw teeth, sweeps off the adhering cotton wool from the teeth of the saws by revolving in the opposite direction to the saw roller. The cotton seed as picked from the pods is thrown into the hopper E, and the saws in turning round snatch the filaments from the seed which remains against the grid, and drag them inwards and upwards. The stripped seeds being too large to pass through the grid accumulate at the bottom of the hopper E and are let out at intervals.

For the purpose of "ginning" the cotton, or separating the cotton fibres from the seed, the "roller gins," as they are called, are of the most primitive construction, simply and ingeniously made, and are of Indian origin. Fig. 2 shows a section of a roller gin of modern construction, drawn half full size. It is formed of two small rollers about ⅝in. diameter and from 6in. to 9in. long, made to revolve in opposite directions, as shown by the arrows, by means of toothed wheels. The bottom roller turns on fixed bearings, and the upper roller is kept in close contact with it by means of a lever and screw. The cotton seeds are fed forwards between the rollers from the table in front, a space being left between the edge of the table and the bottom roller to allow the seeds to drop down as they become cleaned of the cotton fibres by the revolving action of the rollers. A brush is fixed underneath the bottom roller to brush off any cotton fibres adhering to its surface. It is necessary that gins acting in this way should have rollers of small diameter, say from ⅝in. to ⅞in., because the smaller the rollers, the more obtuse is the angle they present to the seed which is being cleaned, and the seeds are thereby better prevented from being drawn in between the rollers and crushed and mixed up with the cotton fibre. It is evident, in referring to Fig. 3, that large rollers present an acuter angle to the seed, and with such rollers the seeds would unavoidably be drawn in and crushed and mixed with the fibre. The great object to be attained in ginning cotton is to get it free from all impurities; and it is found that the smaller the rollers and the slower their motion the cleaner is the cotton fibre separated from the seeds; for if the rollers are above an inch in diameter, and if they revolve very rapidly, they draw in soft, small, and false seeds, crushing them in their passage, and straining and otherwise injuring the cotton fibre.

The most improved gin of the roller class is shown in Fig. 4, drawn half full size, and is constructed with one large roller covered with leather and having small spiral grooves formed round it both right and left. A guard plate A is fixed near the surface of the roller, having a grating along its bottom edge just wide enough for the seeds to pass through to the roller; and between it and the roller a thin steel striker blade B vibrates a short distance up and down with a rapid motion. By this means the seeds are shaken and turned round in contact with the surface of the roller revolving in the direction of the arrow, and the cotton fibres are drawn between the blade B and the roller, while the stripped seeds are rejected and drop down through the space between the blade B and the edge of the feed table, having been thus cleaned of their fibres in a most thorough manner.

The cotton after a further process of cleansing and carding is then ready to be operated upon by the drawing frame, shown in Fig. 8. Five or six cans F placed side by side contain each one sliver of cotton as delivered by the carding engine, and the several slivers are drawn together and combined into one by passing through the drawing rollers G, from which the combined sliver is conducted by the funnel and rollers H into the can I, in front of the drawing frame. This process is repeated by combining five or six of the new slivers into another compound sliver by passing them a second time through drawing rollers; and for the manufacture of the finer descriptions of yarns this drawing process is repeated as many as half a dozen times.

In the construction of the drawing rollers G, Fig. 9, the lower roller, which is the only one driven, is of iron and fluted on the surface; the top roller, which has a soft yielding surface, is driven only by friction from the lower roller, upon which it is pressed by a weight J suspended from a bearing in the centre of each roller, as shown half full size in Fig. 9. The pair of rollers are shown in elevation half full size in Fig. 10, K being the centre bearing from which the weight is suspended; and the ends of the top roller are plain pivots L L working between vertical guides over the centre of the bottom roller, and free to move vertically as seen in the transverse section Fig. 9.

In the first introduction of the new system of drawing cotton by rollers a great difficulty to be overcome consisted in the cotton lapping round the rollers during the drawing instead of being delivered clear of them; and there was also the difficulty of finding a material for the top rollers that should have an elastic surface and yet be durable and perfect in its action, imitating the delicacy of touch of the human fingers in the original distaff spinning, by giving constantly the exact amount of pressure required for drawing the fibre uniformly, so as not to over stretch the thread and thereby vary the thickness of any portion. Top and bottom cleaners M, Fig. 9, consisting of a rubber of flannel fixed on a board lying upon the top roller and held up under the bottom roller by a weight, were applied to prevent the cotton from lapping round the rollers; and previously it had been the practice for the attendant to rub the roller occasionally with chalk, which was the plan adopted by Arkwright and continued long after his time. The application of top and bottom cleaners has to a great extent removed that evil.

The construction of the rollers is a point of great importance, upon which the success or failure of the drawing process really depends. The ordinary top rollers are those made with an iron centre, painted with white lead and covered with thick felted flannel made for the purpose, over which is placed a cover of specially prepared leather. The importance of good top rollers in spinning cannot be over estimated; but as hitherto constructed in the manner just described they have several radical defects, which make it impossible to spin or draw cotton of uniform thickness or "counts." The top rollers are made in pairs with two roller surfaces or "bosses," as they are termed, upon one spindle, and as ordinarily constructed these two bosses are solid upon the spindle. Practically it is impossible to get the two bosses of exactly the same diameter when clothed, owing to the varying thickness of the leather. Then if one of them be $\frac{1}{16}$th inch larger in diameter than the other when covered, the result will be a contention for speed between the two bosses; for by the time one has made 20 revolutions the other wants to have gone 21. This causes slipping and abrasion of the surface of the leather, which causes the cotton to lap round the roller, and wastes the fibre of the cotton drawn, besides destroying the leather; and the roller also gives out irregular lengths of yarn or sliver. Again the ordinary roller requires oiling many times a day, owing to the bearings being all external and soon getting dry from the flakes or particles of cotton collecting about them and soon absorbing the oil; and in proportion as the bearings get dry the top roller drags and loses its speed, and the yarn or sliver becomes thicker. When oil is applied, the roller goes freely for a time, giving out a greater length of sliver. By this frequent necessity for oiling not only is a great waste of oil occasioned, but the oil saturates and helps to destroy the cloth and leather covering of the roller, producing extra sticking and waste of the cotton.

Figs. 10 and 11 show half full size the most improved construction of these top rollers, the invention of Mr. Evan Leigh, of Manchester. NN are the two bosses of the top roller, which are both loose upon the spindle, and GG is the corresponding bottom roller. The bosses of the top roller in this case revolve entirely upon the spindle, and the spindle remains stationary, instead of revolving within the hook that carries the weight and between the end guides as in the old plan. A section of one of the bosses of the top roller is shown in Fig. 10, showing the conical form of the end journals LL of the spindle, which in conjunction with the coned holes at the ends of the rollers gives a capillary action, always drawing the oil from the end bearings L inwards into the parallel portion of the spindle inside the roller. The inner ends O of the spindle are coned down in a similar manner, and the oil is thus prevented from escaping from either end of the rollers. The body of the rollers NN is of cast iron, bored out with great accuracy and care, and is covered first with flannel and then with leather. The spindles are also of cast iron, and the weight for giving pressure to the top rollers is suspended from the centre K between the two bosses. Each boss N can now run at its own speed independent of the other, and thereby each delivers out correctly its proper length of sliver. The leather keeps smooth, and saves waste of cotton; and the bearings being internal and completely covered, the rollers do not require oiling for weeks. These top rollers save the couplings of the lower rollers by taking less power to drive them, and avoiding the retarding action, like that of a brake, which was produced by the upper roller slipping over the fluted surface of the lower roller to the extent of the variation in diameter of the bosses on the upper roller. The spindle being made of cast iron as well as the roller, the tendency to wear is reduced to a minimum; for when two surfaces of cast iron have worked together a short time, the oil becomes absorbed in the pores of the metal, which attains a high polish, runs light, and becomes as hard and indestructible as glass. These top rollers run from one to six months without lubrication, according to the quality of oil used.

Another difficulty that spinners have had to contend with is the fluting or cutting up of the leather surface of the top roller by the action of the flutes in the bottom roller. When this occurs the fibres of the cotton get crimped and cut or broken in the act of being drawn, by passing between the two corrugated surfaces, and a greater length of thread is delivered than when the top roller is kept perfectly smooth; but the spinning of good yarns depends upon the regularity of all the threads as to quantity of fibre and length delivered. The bottom rollers were formerly fluted by longitudinal grooves cut with a tool at equal pitch all round the roller, and the impression left upon the top roller was consequently of uniform pitch, and continued deepening by the pressure of the corrugations always coming upon the same parts.

About twenty-five years ago a simple method of fluting the bottom rollers irregularly was introduced with a view to remove or correct the fluting of the leather rollers; this plan is illustrated in Figs. 12 and 13. The ordinary roller fluting machine may be said to be an ordinary planing machine with the addition of a ratchet motion to turn the roller from one flute to the next after each cut. The method of fluting the rollers with irregular flutes was as follows:—A disc P was keyed upon the end of the roller G, on which a ratchet plate R was placed eccentric to the centre S of the roller and disc P. The click T of the ratchet moved the ratchet one tooth round after every cut of the tool U, and thus the flutes nearest to the centre of the eccentric ratchet R were closer together than those further removed from that centre, and therefore the more eccentric the ratchet the greater was the disproportion of the distances between the flutes. This is illustrated by the two segments shown in Fig. 12, which at their outer extremities are the same width, namely, the breadth of one tooth of the ratchet R; but where they intersect the circumference of the roller

at V and X, the distance of V from the centre of the ratchet being double that of X, the breadth of the segment at that point, and consequently the pitch of groove cut, is also doubled. This arrangement, to a certain extent, obviated the tooth and tooth action which took place in the ordinary regular fluted rollers, the irregular pitch of the flutes in the new method causing their impressions upon the top roller to vary in position at each revolution; but it was not effective in saving the top roller unless there were considerable difference in the breadths of the flutes, which gave rise to another evil, namely irregular drawing of the cotton fibre: in fact in this plan a bad drawing roller was used to save the top roller.

The latest improvement in the fluting of spinning rollers was introduced by the writer about three years ago and is now being extensively adopted. Up to that time all rollers for drawing cotton and other fibres had been made with straight flutes parallel to the axis of the roller. The improvement now made in the fluting consists in forming the flutes spirally on the rollers, at an inclination of about 1 in 12 to the axis of the roller, as shown in Fig. 10, the grooving being done in the ordinary fluting machine with the simple addition of a twisting motion for the roller while in the act of cutting, similar to a rifling action in gun manufacture. By this means the upper roller rests upon several flutes at once, their number depending upon the length of each roller and the length of twist of the spiral flutes, instead of resting upon one straight flute as in the ordinary roller. In the ordinary roller, the flutes being parallel to the axis, the upper roller must make a slight ascent and descent in passing over the top and groove of each flute; while with the spiral flutes the top roller is uniformly supported and will not have the least rise and fall. A further improvement is made by inclining the flutes of one roller in the reverse direction to those of the next, as shown in Fig. 10; so that by turning end for end the top rollers, which are in short lengths, any tendency of the leather to flute may be corrected, since the flutes formed by one roller would be wholly or partly effaced by the reverse spiral of the flutes in the other roller.

All the forms of rollers that are grooved in a planing machine have a defect from the edges of the grooves being left keen with a slight burr upon them, which would cause the cotton fibre to adhere to the surface of the rollers. To prevent this a careful and tedious hand process has to be gone through with each roller, after cutting the flutes, in order thoroughly to smooth down the grooves by longitudinal rubbing with stone and emery; and the rollers are then polished by revolving in the same direction in which they intended to run in working.

A very rapid method of manufacturing these spiral fluted rollers by means of a milling tool has been introduced by the writer, in which the whole process is completed at one operation, leaving the roller finished ready for putting to work without any intermediate preparation being required. The machine for this purpose is represented in the front elevation, Fig. 5, and the transverse sections, Figs. 6 and 7; and Figs. 14 and 15 are enlarged views showing the details of the milling process, drawn half full size. The roller A to be fluted is laid on friction rollers B B, Figs 14 and 15, supported by adjustable stands upon a saddle C C fixed on the main bed of the machine, Figs. 5 and 6. The milling tools are steel discs about 2in. diameter and ⅜in. wide on the edge which has upon it a counterpart of the flutes to be impressed upon the roller. Each milling tool is carried by a cranked lever E working on a centre at E, Figs. 6 and 7, and acted on by the weight F, which exerts a downward pressure upon the milling tool of about 1,200lbs., regulated by shifting the weight F to the extent required. The milling tools are thrown out of action by the eccentric shaft G being turned half round, which depresses the tail end of each of the four levers E, lifting the weights F, and raising the mills D from off the roller, as shown in Fig. 7. The mills are first placed about ¼in. upon the ends of each roller to be cut, as shown dotted in Fig. 14; four roller bosses all on one solid spindle are milled at one and the same time. The roller to be milled is turned by the driving pulley H, Fig. 5, through a universal joint I, in order to prevent any strain upon the roller during the process. The milling tools with their levers and weights are all carried by a sliding carriage J J, and traversed along the bed of the machine by a screw K with a self-acting feed, as in an ordinary slide lathe. When the carriage J has traversed the length of one of the bosses of the roller, the machine is stopped by the handle and strap rod L; and the mills are lifted up from off the roller by turning the eccentric G. The carriage J is then moved forwards by the handle M, on which is a pinion working into a wheel on the same shaft as the crown wheel N gearing into the traversing screw K. The four mills are thus brought into a position to start milling the four remaining bosses of the roller. The weights F are then let down, causing the mills to bear on the roller; and the crown wheel N being locked by the handle O, the carriage J will then traverse the mills over the bosses. The mills work at the rate of 60 revolutions for one inch of traverse, the roller revolving at the rate of about 120 revolutions per minute; and the mills being about double the diameter of the roller, the fluting advances about $\frac{1}{120}$th inch in each revolution of the roller.

Rollers manufactured in this way by milling have a much harder surface and will consequently wear much longer than those fluted by the ordinary cutting system, the surface of the metal being condensed by the pressure in the milling process. Another advantage is that the grain of the iron is laid in the best direction for ensuring smoothness of action in the working of the roller, since the roller is driven in the milling process in the same direction in which it is intended to run in the drawing frame; and the mill leaves it sufficiently polished to be immediately used for drawing.

The drawing rollers are from 1¼in. to ⅝in. diameter, and 16in to 22in. length, with from two to eight bosses of proportionate length upon each; and the several rollers are coupled together by square spigot and socket joints formed on the ends of the rollers, extending to a total length of 30ft. to 120ft., all driven from one end. The manufacture of spinning rollers has of late years been much improved by the introduction of special self-acting tools for each operation. First, the bar of iron is cut up into lengths, which are then heated and rolled between three rollers to make them true and straight. Secondly, rough squares are forged at one end of each bar with a Ryders's hammer, to form the spigot. Thirdly, each bar is cut to the exact length required, and a hole is bored up longitudinally about 3in. at the other end, six rollers being bored at a time in a multiboring machine. Fourthly, the round holes thus bored are squared out for the coupling by means of three punches, each punch larger and shorter than the preceeding, so as to allow room for the shavings to lie at the bottom of the hole. The last punch does not entirely square the hole, leaving a space to allow the air to escape from behind the punch in order to prevent risk of bursting the socket; and thus a portion of the original circle is retained on each side of the square socket for centuring the roller truly in the subsequent turning process. For squaring up the spigot end of each roller, four or six of the rollers are put upon a machine with as many vertical tools, and two opposite sides of the square are cut at once by a pair of tools, the roller being carried by the centres at the ends so as to ensure the square being truly central with the roller. The roller is then turned one quarter round and the remaining two sides are cut in the same manner as the two former ones. The rollers are then fitted into one another, and marked as they are intended to work in the spinning machine; and they are turned in pairs to ensure their running true. They are then ready for the fluting machine already described.

Figs. 16 and 18 show a set of drawing rollers drawn full size. P and R are the carrying rollers, in which the top rollers are sometimes made of iron, smooth or corrugated, and sometimes covered with leather, P being the back or feeding rollers; and S are the main drawing rollers, the upper one covered with leather, which run about seven times the surface speed of the first rollers P. In Fig. 16 the three pairs of rollers are placed close together for short fibred cotton, and Fig. 18 shows them further apart for long fibred cotton. As the different qualities of cotton vary in length of fibre from ⅝in. to 1½in. the proper adjustment of the rollers is absolutely necessary for perfectly attenuating the mass of fibres passing through the drawing rollers. The distance from the centre of one pair of rollers to the centre of the next pair, or the "nip" of the rollers, as it is called, should in no case be less than the greatest length of the cotton fibre, or else the fibres would get broken or pulled asunder by being still held by the back rollers when caught at the front end by the drawing rollers running at the higher speed. If, on the other hand, the successive pairs of rollers were too wide apart, the shorter fibres would not be taken hold of in a perfect manner, not being caught hold of by the quick rollers soon enough after being let go by the former rollers, thereby making a false or irregular thread.

A set of drawing rollers and a bundle of fibre is shown in Fig. 17, the rollers being drawn full size, with the actual distance between the successive pairs longitudinally, but with the vertical space between the two rollers in each pair exaggerated for the purpose of illustrating the nature of the drawing action. P P are the back or feeding rollers, and S S the main drawing rollers.

It is of the greatest importance for the production of good and regular yarn that the sliver of cotton fibre should be regular in thickness, and also fed in with a regular continuous motion. In order to illustrate the action more clearly, the fibres are represented in the diagram, Fig. 17, alternately white, shaded, and black; and the length of the fibre corresponds with the distance from centre to centre of the successive pairs of rollers. The number of fibres in the sliver entering the feed rollers P P is represented as 10 in the diagram; and the ratio of speed of the second pair of rollers R R to that of the first pair being taken for the purpose of the diagram as 10 to 7, the fibres get drawn out past one another until they represent 7 fibres in thickness under the second pair of rollers R. The third pair or main drawing rollers SS run quicker than the second pair in the assumed proportion of 7 to 3, and consequently the fibres passing through the third pair S are represented by 3 in thickness of sliver. Thus the sliver or bundle of fibres in passing through the three set of rollers would in this case be diminished in thickness in the proportion of 10 to 3, and increased in length in the same proportion: so that the greater the difference of speed between each pair of rollers, the finer is the yarn produced. In practice the third or main drawing rollers S run about seven times the surface speed of the first rollers P, as previously stated; so that the sliver of fibres is reduced seven times in thickness of fibre, and increased seven times in length. It is said that the first inventors of the drawing rollers got their ideas from the action of rollers drawing or rolling iron; but it is evident that the drawing out of the fibres of iron for the purpose of elongating a dense mass of material is performed on a very different principle from the drawing action produced by a series of rollers running at different speeds on a large number of short loose fibres of fragile texture.

The spinning of short fibre cotton is practically limited by the smallest diameter that the drawing rollers can be made, so as still to allow of constructing coupling sockets in the several lengths of the rollers, sufficiently strong to transmit the power required for a long length of rollers. The great bulk of the cotton machinery in this country is made for drawing cotton having a length of fibre or staple of 1in. to 1½in., comprising the better qualities of cotton, namely

New Orleans and African cotton	1in. to 1¼in.	length of fibre
Brazil	1in. „ 1½in.	„
Egyptian	1in. „ 1⅝in.	„
Sea Island	1½in. „ 2⅛in.	„

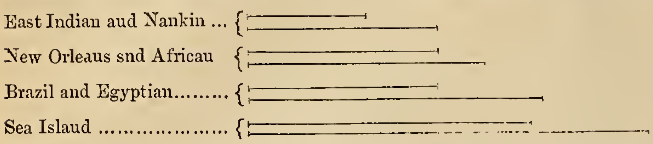
as shown full size in the diagram. But the cotton from the new sources of supply now being introduced has a much shorter length of fibre, namely

East Indian and Nankin cotton ...... ⅝in. to 1in. length of fibre;

and for the purpose of drawing this cotton it is requisite that the diameter of the rollers should not exceed ⅝in., in order to bring them close enough together to deal with ⅝in. fibre. The roller bearings are made to slide transversely, as shown in Fig. 9, so as to be accurately adjusted to the particular length of fibre in each sample of cotton to be drawn; and the rollers have to be small enough for the shortest fibre intended to be drawn.

Wrought iron is not satisfactorily applicable to rollers of so small a size as ⅝in. diameter when carried to a great length; for in addition to the weakness of the

couplings the total amount of torsion in a long length of rollers causes the time of action to be sensibly different at the two extremities of the machine, so that the delivery is too slow in starting at the far end, thus giving an undue stretch upon the yarn and occasioning breakage at those parts. To obviate this difficulty a trial has recently been made by the author's suggestion of Bessemer steel



instead of wrought iron as the material for the rollers and this has been successfully adopted in some mills. Steel rollers have been formerly tried in few cases, but the great expense prevented their adoption; whereas the moderate cost of the Bessemer steel admits of its use, while its fine homogeneous quality renders it specially suited for the purpose. A sample of these rollers is exhibited, together with working models of a box or set of drawing rollers, throstle rollers, and mule rollers.

SOCIETY OF ARTS.

ON THE INJURIOUS EFFECTS OF SMOKE ON CERTAIN BUILDING STONES AND ON VEGETATION.

By Dr. Augustus Voelcker, Consulting Chemist to the Royal Agricultural Society of England.

Much has been said and written on the causes of the rapid decay to which some building stones are liable. Chemists, mineralogists, architects, builders, and other scientific and practical men have on various occasions devoted a good deal of time and painstaking labour to investigations, purporting to trace the beginning and progress of this decay, and to discover, if possible, the means of preventing the injury which calcareous building stones sustain under the influence of the atmosphere. Their labour has not been altogether unsuccessful, and several suggestions, of more or less value, have been made, which are well calculated to mitigate, if not to prevent, the evil. Still our information on the true character of the decay in particular stones is but scanty, nor are the means of preventing decay in buildings so perfect as not to call for further improvements.

Every addition to our knowledge of the causes of decay in stones has a tendency to bring within easier reach the appropriate remedy. At all events, a more comprehensive knowledge on this subject in stones will help us to discriminate with more certainty between good and bad stones, and to avoid the employment of building materials which, although they stand the influence of the weather very well in the open country, are nevertheless unfit for particular parts of a building, and cannot be used with safety in some localities. Having been engaged for some time past in examining the characteristic black crusts which are frequently seen on buildings erected of Bath and similar oolitic limestones, my attention was specially directed to the study of the nature of the decay which attacks with great energy some kinds of calcareous stones, and I have come to the conclusion that the injury which the smoke of towns exerts on Bath stone, magnesian limestone, and other calcareous building stones, is far more pernicious in its result than it is generally believed to be. It will, therefore, devolve upon me to direct your attention particularly to the changes which such stones undergo under the influence of a smoky atmosphere, such as we find in most towns.

In every day life we usually understand by smoke, the black and more or less tangible impure air which rises from the chimneys of fire-places and furnaces in which the combustion of the fuel is imperfect, in consequence of which some finely-divided carbon and a variety of gases are thrown into the air.

That this black smoke exerts an injurious influence on building stones and on vegetation, is admitted in a general way, but I have no hesitation in saying that the extent of the injury done by the smoke that at times obscures the sky in our crowded cities has not been fully recognised. This, perhaps, is the reason why the precise chemical changes produced by accumulations of soot on limestones and calcareous sandstones have not been studied with sufficient minuteness.

Before giving an account of my analytical experiments on the effect of smoke on oolitic limestones, a few general observations on the nature of the decay in stones may not be out of place.

Building stones in general may be divided into two classes:—

1st. Stones which, like granite, porphyries, and most sandstones, are not easily acted upon by acids.

2nd. Stones which, like limestones, dolomites, and some kinds of calcareous sandstones, are composed of materials that are partially or entirely attacked by acids with facility.

Building stones belonging to the second class are much more liable to suffer injury by atmospheric agencies than those belonging to the first class; and as, moreover, limestones and dolomites are principally employed for ornamental buildings, the investigation of the causes which lead to their decay possesses a special interest.

The conditions under which calcareous stones decay when placed in a building are partly mechanical and partly chemical. The absorption of moisture by porous stones, and the disintegration to which it leads in consequence of the resistless expanding force of water in becoming ice in cold weather, are illustrations of a purely mechanical cause and effect, which frequently manifest themselves in limestones used for building purposes. The changes produced on building stones by carbonic acid and the sulphur compounds in the air of towns, are instances of chemical reactions, which may be seen in their results in some cases as distinctly as the results of purely mechanical force, to which allusion has just been made. Building stones of a loose or irregular structural composition are of course more liable to suffer injury from the absorption of moisture than hard, compact, and crystalline stones of the same or similar composition. The more readily a specimen of Bath or Caen stone is affected by mechanical agencies the more easily it will be found to be acted upon by chemical re-agents. It will not, therefore, be necessary, nor indeed desirable, to examine separately the mechanical and the chemical conditions of decay. I would, therefore, notice together the physical and the chemical effects likely to be produced in calcareous building stones by the different constituents of the atmosphere.

Of the normal component parts of air, oxygen, moisture, carbonic and nitric acid have to be regarded as probable agents of destruction. The abnormal or accidental constituents of the air of towns are certain sulphur acids, soot, and occasionally hydrochloric acid. These accidental impurities require particular examination, as they are really more pernicious in their effects upon building stones, as well as on vegetation, than the normal constituents, which, it need hardly be observed, exert no injurious influence upon vegetation.

The action of oxygen is of comparatively a subordinate character, its effects being confined to constituents usually absent or occurring only exceptionally, and in but small quantities in limestones and dolomites. In calcareous sandstones sulphides of iron and protoxides of iron and manganese are occasionally found, and as these compounds are very prone to absorb oxygen, and the higher oxides thus formed are more voluminous than the original protoxides, such stones are subject to the disintegrating action of atmospheric oxygen. Of far greater importance are the effects of moisture. Water, either in the shape of vapour or liquid, perhaps is the most powerful agent of destruction that displays itself in the gradual crumbling down of calcareous stones. Porous and soft stones of that kind should never be employed for parapets, window sills, weather beds of cornices, strings, plinths, or other parts of a building where water may lodge. The changes which water produces in porous stones exposed to drip and alternations of a wet and dry condition appear to be less of a chemical than a mechanical character.

Water is subject to expansion on sudden alterations in the surrounding atmosphere, and the irresistible force it then exerts, necessarily exercises a disintegrating action. If the temperature sinks below the freezing point, this destructive action is most powerful, since water in becoming ice suddenly and greatly expands. But even above the freezing point, the expansion of water at a sudden elevation of temperature appears to me to exert, upon porous building materials, a mechanical force sufficiently powerful to account for their gradual decay, at seasons of the year when it cannot be referred to the formation of ice within the pores of the stone. There can be no doubt that all stones which possess in a high degree the property of absorbing moisture, are unfit for building purposes. Certain kinds of porous limestones and sandstones, differing widely in composition and in relation to their liability to become attacked by acids, are alike subject to this disintegrating action, thus indicating plainly that their decay is not the result of the chemical action of an atmospheric constituent, but the result of the mechanical action which water exerts on all porous and absorbent materials, no matter what their composition may be.

Such stones, it will be readily conceived, must be very liable to crumble down in our moist and changeable climate. In towns, and in the country in sheltered or in exposed parts, on the outside or the inside of buildings, and in short under the most varied conditions, the decay will proceed steadily when it has once begun to show itself in porous and absorbent stones. The fact that these building stones decay as readily in open country places as in towns, has led some men to entertain the opinion that the impurities present in the air of towns and in the immediate neighbourhood of manufacturing districts have nothing to do with the gradual disintegration to which oolitic and other calcareous building stones are subject. But although it is quite true that some building stones do not require to be exposed to the injurious effects of the atmospheric impurities of crowded cities in order to decay, it is no less certain that there are others which stand wind and weather well in the country, but are more or less readily attacked by atmospheric influences when employed in the erection of town residences.

The fact is, the structural composition of some stones is so irregular, and radically bad, and their absorbent powers of moisture so great, that they are alike unfit for the erection of buildings in town or country, whilst there are others possessing sufficiently good physical characters to resist the mechanical effects of water, to which reference has been made, and of remaining sound in a comparatively speaking pure air, but which are not of such a chemical composition as to be capable of withstanding the pernicious chemical influence of a less pure town atmosphere.

Carbonic acid is a never-failing constituent of the air, and consequently is present also in rain-water. Much stress has been laid on the dissolving action of rain-water, but it appears to me this action has been greatly overrated. Instead of practical proofs, showing that water charged with carbonic acid really exerts a powerful disintegrating influence upon calcareous stones, merely theoretical reasonings have been advanced in support of that opinion.

It is true, water charged with carbonic acid in contact with carbonate of lime or magnesia gives rise to soluble bicarbonates, but even were the quantity of bicarbonate of lime or magnesia much greater than it actually is, the mere removal of a trifling portion of lime from the surface of the stone, does not, I take it, explain the peculiar exfoliation and corroded appearance which many oolitic building stones present to our view. Calcareous stones, exposed to the long-continued dissolving action of water containing carbonic acid, exhibit rather a smooth and not a corroded appearance.

In the next place we have to consider the effects likely to be produced by the small quantities of nitric acid which are invariably present in the atmosphere. The proportion of nitric acid in the air is so minute that it may be questioned whether these minute traces have any marked influence on our buildings. With respect to the supposed corrosive action of the nitric acid of the air, and the formation of nitrates in limestones, I made some experiments, a brief account of which may here find a place. A few years ago my attention was directed to

the decay of the oolite limestone of which the lodge at one of the entrances at Badminton is built. This stone was quarried at a place about two miles from Badminton, and, like all Bath stone, is not very hard. The stone protected by the porch of the lodge I found in a more advanced state of decay than that freely exposed to wind and weather. Blocks from under the porch and the exposed part of the lodge were obtained and examined by me for nitrates. Of each block a portion of the exterior side in contact with the air, and the interior side touching the remainder of the thick walls of the lodge were examined separately, and the following results were obtained, by adopting Dr. Pugh's accurate method for determining minute quantities of nitric acid:—

No. 1. Stone from under the porch of the lodge—

	Per centage of nitric acid.	Mean.
a. Interior side	·1786	·2256
b. Exterior side	·2726	

No. 2. Stone unprotected by the porch—

a. Interior side of the stone	·1269	·1480
b. Exterior side exposed to the air	·1692	

It will be seen that both blocks contained small quantities of nitric acid, which probably is a never-failing constituent of calcareous stones. It will also be observed that the stone protected by the porch contained rather more nitric acid than that freely exposed to the weather, and likewise that the external side of both blocks contained somewhat more nitric acid than the interior sides. These results agree well with what may be expected to take place under the different conditions in which the several portions of the stone were found. The sides in contact with the air might naturally be expected to contain more nitric acid than the inside not so thoroughly penetrated by the air, and the circumstance that less nitric acid was found in the stone not protected by the porch, is probably explained by the removal of some of the soluble nitrates by the rain striking against the exposed surface. It has been stated already that the protected stone was more affected by decay than that not protected by the porch of the lodge. Thinking it just possible that the two blocks might differ in composition, I analysed a portion of each, and obtained the following results:—

	No. 1. Limestone under porch.	No. 2. Limestone unprotected.
Moisture	1·46	·81
Oxides of iron and alumina	·98	1·81
Phosphoric acid	·14	·18
Carbonate of lime	93·91	94·64
Sulphate of lime	1·34	1·24
(Containing sulphuric acid)	(·79)	(·72)
Magnesia	·73	·77
Nitric acid	·225	·148
(Mean of the two determinations)		
Insoluble siliceous matter	·97	·95
	99·755	100·548

The differences in the chemical compositions of the two stones are too trifling to account for the greater injury which that protected by the porch had sustained; nor do I think it at all likely that the small quantities of nitric acid which were found had anything to do with the decay of the stone. For confirmation of this the following result may be mentioned:—One of the stones was kept as a specimen in a damp room for rather longer than a year, during which period a considerable portion crumbled down to a coarse powder. In the expectation of finding the process of nitrification to have caused the disintegration of the stone, I made a careful nitric acid determination in this powder, and was disappointed in not obtaining more than ·192 per cent. of this constituent, showing that the proportion of this acid had not sensibly increased, and that the crumbling down of the stone was not connected with an increased nitrification, but more probably the result of the dampness of the room in which the specimen was preserved. Here then we have an example of a limestone crumbling down by degrees solely under the influence of damp. There was no deposition of soot on the stone, and no chemical action of any of the constituents of air, except moisture, could be observed to have taken place.

In the next place the foreign or accidental impurities of the air of towns will have to be considered.

The quantity of sulphur-acids in the air of towns is quite appreciable. The quantity of coals consumed in London for domestic and manufacturing purposes exceeds three million tons per annum, and as all coals contain sulphur, the greater portion of which is discharged during their combustion as sulphurous and other sulphur-acids, an enormous quantity of these destructive acids must find their way into the air. No numerical data exist with regard to the proportion of sulphur-acids in the London atmosphere, but, according to Dr. Angus Smith, the air of Manchester contains an average proportion corresponding to one part of sulphuric acid in every 100,000 parts of air, which, in the centre of the town, rises to 25 parts in 100,000. According to the quality of the coal and the amount consumed in a given space in a given locality, the proportion of sulphur-acids in the air of towns will vary. In some places it may, no doubt, be greater, in others less than in the air of Manchester, but under all circumstances it will be sufficiently large to cause serious apprehensions.

The strong affinity of sulphuric acid for lime and magnesia renders it a destructive agent for calcareous building stones. Sulphuric acid not only renders soluble these earthy carbonates, but, forming with lime gypsum, a compound which contains in round numbers 20 per cent. of water of crystallisation, and with magnesia the well-known sulphate of magnesia, a salt remarkable for the large proportion of water, of crystallisation which it fixes, it gives rise to a mechanical destruction of Bath stone and magnesian limestones similar in every respect to that produced by freezing water. The efflorescences of sulphate of magnesia which have been noticed upon those portions of magnesian limestones where exfoliation has taken place, afford a practical proof of the destructive action of the sulphuric acid that occurs in the air of towns. Hydrochloric acid occasionally has been found in the air of towns. It is, however, not a usual impurity; and as on the 1st of January the act passed in the late session for the more effectual condensation of muriatic acid gas in chemical works came into actual operation, and there is no practical difficulty in securing the condensation of this gas, no fear need be entertained that the buildings in towns will be affected by hydrochloric acid fumes.

Still more pernicious in its influence than the free sulphur acids which exist the air of towns, I have reason to believe is the black smoke which deposits soot, the great disfigurement of our public and private buildings. The soot deposit is particularly destructive to the carved portions of buildings. In order to render intelligible the peculiar chemical action which smoke exerts on calcareous building stones, I beg to invite attention to the following analysis of a sample of ordinary house-coal soot, which I made many years ago. In 100 parts of soot I found—

Moisture	10·620
Organic matter (chiefly black carbon)	44·736
Chloride of ammonium	·933
Sulphate of ammonia	3·580
Chloride of sodium	·231
Chloride of potassium	·503
Oxides of iron and alumina	15·691
Sulphate of lime	11·051
Phosphate of lime	·530
Carbonate of lime	1·129
Lime in a state of silicate	2·290
Magnesia in a state of silicate	·389
Soluble silica	4·014
Insoluble siliceous matters	4·159
	99·856

The per centage of sulphate of ammonia in different samples of soot I find varies exceedingly. In some samples I have found as much as ten, twelve, and even more of sulphate of ammonia. Perhaps 5 or 6 per cent. represents better the average quantity of ammonia than the figures in the above analysis. Soot is essentially a mechanical mixture of finely-divided carbon with sulphate of ammonia, some sal ammoniac, and fine particles of coal-ashes. Soot, it need hardly be remarked, is a constituent of the smokey atmosphere of towns, and is calculated to do great injury to the ornamental work of buildings executed in Bath stone or magnesian limestone. The most destructive agent of such a smoky atmosphere, as far as calcareous building stones are concerned, I am inclined to think is the sulphate of ammonia, which, as has been shown, is a constant constituent of soot. This conclusion has been forced upon me by the examination of the sooty deposit found on a magnificent church in a large commercial and manufacturing town. This church is built of an oolitic limestone found in the neighbourhood, and on account of the increasing decay, which has quite disfigured the structure, and in many places effaced the finer delineations of the carved work, is now under the process of restoration. On some of the older parts of the church the corrosive agents of a smoky atmosphere appear to have penetrated the stone to a considerable depth. The stone here appears to be covered with black crusts, varying in thickness from half an inch to more than an inch and a half.

The church on which these crusts occur is built with a good limestone, composed chiefly of carbonate of lime, with no more sulphate of lime, magnesia, oxide of iron, and insoluble siliceous matters than generally occur in the better descriptions of oolitic limestones, as will be seen by the following analysis:—

Water driven off at 212°	·230
Water of combination	·110
Carbonate of lime	97·690
Sulphate of lime	·153
Magnesia	·470
Protoxide of iron	·540
Alumina	·120
Soda	·044
Potash	·296
Insoluble siliceous matter (silica)	1·350
	101·003

In the course of years this stone becomes covered, as has been already stated, with a dark-coloured incrustation, which increases in depth from year to year. These black crusts are soluble to a large extent in water; in some specimens I found as much as two-thirds soluble in water and only one-third insoluble. Dried at 212° they yielded the following results:—

Portion soluble in water	65·94	
Sulphate of lime		51·23
Sulphate of magnesia		1·61
Chloride of sodium		·47
Water of combination		12·63
Portion insoluble in water	34·06	
Organic matter (black carbon)		5·72
Oxides of iron of alumina		2·57
Carbonate of magnesia		·10
Carbonate of lime		19·03
Insoluble siliceous matter		6·64
		100·00

A comparison of the composition of the crusts with that of the stone upon which they were fonnd deposited, suggests the following remarks:—

1. The greater part of the carbonate of lime, which is the chief constituent of the stone, has become changed into sulphate of lime. Sulphate of lime and and water of combination are given separately in the preceding analysis, both haviug been obtained by direct and separate determinations. Uniting the two together we have no less than 63·86 per cent. of hydrated sulphate of lime; and only 19 per cent. of carbonate of lime escaped trausformation into sulphate.

2. Nearly the whole of the magnesia in the crusts is preseut as sulphate of magnesia, whilst it occurs in the stone as carbouate.

3. The crusts contained in round numbers $5\frac{3}{4}$ per cent. of black carbon, showing that a large proportion of soot must have come into actual contact with the surface of the stone.

4. Both the amount of oxides of iron and insoluble siliceous matters in the black deposit is very much greater thau in the original stone. An examination of the insoluble siliceous matter has shown that it is of the same nature as the siliceous matter of coal ashes. The fine particles of coal-ashes, it thus appears, are carried into the air along with the carbon and other constituents of soot and deposited on the more sheltered portions of buildings. It has been shown before that house-coal soot contains a considerable proportion of oxides of iron and alumina and insoluble siliceous matters in the shape of fine coal ashes. The occurence of fiue coal-ashes in the black crusts thus shows that soot, of the same general character as house-coal soot, was deposited on the stone.

In soot the amount of sulphate of ammonia is considerable, and as the black deposit on the stone shows plainly the presence of other soot constituents, appreciable quantities of sulphate of ammonia might likewise be expected if this salt did uot act upon carbonate or lime in the presence of moisture. I have examined several deposits on calcareous stoues, but never found more than mere traces of ammonia. The sulphate of ammonia iu the sooty deposit in contact with water and the calcareous stone evidently becomes transformed into volatile carbonate of ammonia which escapes, and sulphate of lime which remains behind. There can be little doubt that such a chemical reaction takes place when a smoky atmosphere comes into contact with a calcareous stone, especially if the stone is porous, non-crystalline, and exposed to damp. The dampest, most sooty, and more sheltered parts of buildings are generally much more affected by decay than the more exposed parts. Now, this would not be case if the gaseous constituents of the air were the chief cause of the exfoliations on limestone buildings, for if this were so, I imagine the most exposed parts of such buildings would be more easily attacked than the less exposed. But if the corroding action of the air of towus is, as I believe, more properly ascribed to the tangible portions of soot, it admits of a ready explanation why exactly the sheltered and damper portions of a building are more liable to decay than other parts. In the first place it is evident that soot will be more abuudantly deposited in the crevices of fine ornamental stoue-work, or in places sheltered by protruding cornices, than ou a plain surface wall, freely exposed to wind and weather; in the next place, it has to be borne in mind that, according to a well-known law in chemistry, chemical reactions do not generally take place except the materials which act upon each other are in the most intimate contact, which necessitates either fusion or solution of at least one of the coustituents.

In a dry position soot does not produce so injurious an effect as in a damp place, where the sulphate of ammonia contained in it is dissolved by degrees, and retained in solution in the porous stone. Acting upon its carbonate of lime, it will produce sulphate of lime and carbonate of ammonia. In a damp and sheltered position, the conditions for the display of this decomposing action of sulphate of ammonia "are" evidently more favourable than they are in a more exposed part of a building, where rain will wash away the sulphate of ammonia of soot before it has time to act upon the stone, and the wind in a great measure will prevent altogether large accumulations of soot.

The sulphate of lime produced by the action of sulphate of ammonia upon limestones in the presence of moisture, it is hardly necessary to observe, takes up water of crystallisation, and thereby leads to the exfoliation of the stone. The longer the action of a sooty atmosphere continues upon limestones, the more complete will be their decompositiou. In old and thick crusts, like those examined by me, we have seen that more than 60 per cent. of gypsum may occur. Had I merely analysed the surface of the crusts, I doubt not a still larger proportion of sulphate of lime would have been found.

In another specimen of a black limestone deposit from a public buildiug, I found:—

Hygroscopic water	1.07
Organic matters (chiefly fine carbon)	5·29
Hydrated sulphate of lime	56·10
Carbonate of lime, oxides of iron, alumina, &c., (determined by difference)	34·11
Iusoluble siliceous matter	3·43
	100·00

The proportion of ammonia in this incrustation amounted to only ·04 per cent., and that of nitric acid to ·115, which is equal to ·174 of nitrate of lime. Here, agaiu, it will be noticed the sulphate of ammonia of the soot has almost entirely disappeared, and given rise to uo less than 56 per cent. of hydrated sulphate of lime.

The effect of a smoky atmosphere on Caen stoue is very injurious, particularly if the stone is porous and hygroscopic. I have lately had an opportunity of noticing the rapid decay of Caen stone employed iu the restoration of a church. The decay showed itself in less thau three years, and was proceeding with such rapidity that this stone had to be abaudoned in the work of restoration.

Specimens of this Caen stone, and incrustations formed upon it under the influence of the smoky atmosphere of a large manufacturing town, are placed on the table; also specimens of the stone which is now employed and which resists better the injurious action of such an atmosphere.

The analysis of the incrustation on the Cacu stone yielded the following result:—

Hygroscopic water	1·56
Orgauic matters (carbon chiefly)	4·54
Hydrated sulphate of lime	41·78
Carbonate of lime	38·93
Carbonate of magnesia	·58
Oxides of iron and alumina	·33
Insoluble siliceous matter	11·01
Alkalies and loss	1·27
	100·00

The amount of alumuia in the deposit was only ·038. A nitric acid determination gave ·246 per cent., which is equal to ·371 of nitrate of lime.

Although this deposit was comparatively speaking of receut production, it nevertheless contained a large proportion of hydrated sulphate of lime. Hard crystalline limestones of course resist the action of smoke better than porous soft stones, but it may be questioned whether any description of limestone is well adapted for delicate ornamental out-door work in a smoky town. If the evil of a smoky atmosphere cannot be entirely avoided in places like Loudou, Mauchester, Birmingham, &c., every care should at least be takeu to mitigate as much as possible the smoke nuisance.

It is uot my intention to examine the various methods which have been proposed to render calcareous building stones less liable to decay, for my chief object has been to bring before your notice an account of experiments which I made in studying the remarkable chemical changes which oolitic limestones undergo under the influence of a smoky atmosphere. I cannot, however, refrain from saying, that, of all the different plaus of protecting buildings against decay, Mr. Ransome's appears best to fulfil the requirements of tho case. In the first place, it may be observed, a remedy against decay in stones should have a tendency to render porous stones more imprevious to water and atmospheric impurities; and, in the second place, such a remedy should alter the surface of a stone which is so readily attacked by smoke as limestones generally are, in a mauuer that, instead of carbonate of lime, a compound of lime is produced on the surface which is not readily acted upon by sulphate of ammonia or by acid fumes which are fonnd occasionally iu the air of towns. Mr. Ransome's patent process appears to fulfil perfectly the first requiremeut—that of making a porous stone harder and more compact. The principle adopted in this process likewise appears to be correct, and in a great measure to fulfil our secoud requirement, for by first impreguating a limestone with chloride of calcium, and saturating it afterwards with a solution of silicate of soda, Mr. Ransome closes the pores of the stone and fills them up with insoluble silicate of lime, a compound which is not acted upon readily by chemical agents. By surrounding the particles of carbonate of lime of which the porous stone consists with insoluble silicate of lime, it will be readily conceived the surface of the stone must be rendered far less liable to be acted upon by atmospheric agencies than the stone in its unprepared state. The perfection of this process would be, if by some means or other, uot ouly the pores of calcareous building stone could be filled up with a compound, which, like silicate of lime, is uot easily acted upon by chemical agencies, but if au appreciable portion of the surface of the stone itself could be changed from carbonate into silicate of lime or into some other equally well-resisting compound, and at the same time the production of soluble salt-like chloride of sodium could be avoided.

In conclusion, I beg to offer a few observations on the injurious effects of smoke on vegetation.

By a recent Act of Parliament provision is made for the effectual condeusation of muriatic acid gas in alkali works; but, as far as I know, there is no law which prevents brickmakers throwing into the air any quantity of sulphurous acid which they choose, although it is more pernicious to vegetation than even muriatic acid gas. I have had many opportunities of becoming practically acquainted with the injurious effects which a smoky atmosphere produces on our cereal crops, aud regard a strong deposition of soot on wheat and other corn crops quite a sufficient evidence of the more or less complete injury which the crops must have suffered by the sulphurous acid always present in the air in districts where such sooty deposits are seen on plants. The disadvantages of carrying on agricultural pursuits iu the potteries, or in districts where volumes of black smoke discharge enormous quantities of sulphurous acid into the air, are well-knowu amongst the more intelligent and enterprising farmers. This fact explains, to a certain extent, the backward conditiou of agriculture in such localities, and loudly calls for a mitigation of the evils to which farmers are exposed who have the misfortune to occupy land in the immediate ueighbourhood of large manufacturing towns, or in localities where immense quantities of inferior coal are consumed by brick and tilemakers and manufacturers of earthern and stoneware, &c. Again, in districts where copper ores, consisting for the greater part of the sulphurets of copper or iron, are the raw materials from which copper-smelters extract the metal, enormous quantities of sulphurous acid are discharged into the atmosphere.

The injury done to vegetation by the smoke from copper-works has been traced beyond a distance of four miles. It is true the smoke from such works generally contains appreciable quantities of arsenic, which of course is inimical to the health of plants; but as the arseuical fumes are insignificant in quantity in relation to the large amount of sulphurous acid which is produced in roasting copper ores, and as air containing $\frac{1}{10000}$ or even $\frac{1}{800000}$ part of sulphurous acid gas is decidedly injurious to vegetation in wet weather, I think the sulphurous acid of copper-smoke does more mischief to the crops iu the ueighbourhood of the works than the arseuical compounds of the smoke. Just as little as alkali-makers are permitted to discharge muriatic acid into the air, should copper-smelters be allowed to discharge into the air the enormous quantities of sulphurous acid which are produced in roastiug certain copper ores. It may perhaps not be possible to condense sulphurous acid so perfectly or so readily

as muriatic acid gas; and probably the arrangements for the condensation of the former will be found altogether inappropriate to effect the condensation of the latter, but attempts to mitigate the evil resulting to vegetation by sulphurous acid fumes should be seriously undertaken.

It has occurred to me that the sulphurous acid fumes of copper-works might, perhaps, be converted economically into sulphuric acid, or be used for the production of sulphite or hyposulphite of soda; and I do not consider it improbable that one of these days this highly injurious product will cease to be a nuisance to the inhabitants of the country round about the works, and be turned to good economical account.

As regards the actual quantities of sulphurous acid gas contained in the smoke of brick-kilns, we possess no data for our guidance. The quality of the coal used, the construction of the kiln, and the composition of the clay of which the bricks are made must affect to a great extent the proportion of sulphurous acid in the smoke. Thus a coal, with a high per centage of sulphur, but containing also much mineral matter, may produce on burning less sulphurous acid than another kind of coal, poorer in sulphur and in mineral matter, inasmuch as the greater portion of the sulphur is fixed by the mineral portion of some coals. Again, if the clay contains magnesia or lime, or is purposely mixed with chalk, most of the sulphur of the coal will be fixed by the magnesia or lime.

The brick-makers in the neighbourhood of London, who use with the clay a considerable proportion of chalk, therefore produce a smoke which contains but very little sulphurous acid, whilst in districts where fire-bricks, tiles, &c., are largely manufactured from clay that does not contain lime or magnesia, or merely insignificant quantities, the air becomes charged with sulphurous acid to an extent which injuriously affects the vegetation for miles round the brick-clamps or kilns.

CORRESPONDENCE.

We cannot hold ourselves responsible for the opinions of our Correspondents.

PRESSURE OF STEAM AT HIGH TEMPERATURES.

To the Editor of THE ARTIZAN.

SIR,—The figures quoted by Mr. Peacock, in THE ARTIZAN for January, from a table of mine in THE ARTIZAN for November last, are not to be regarded as independent data respecting the temperatures corresponding to various pressures of high pressure steam. They are merely a few of the results of a formula which I deduced from M. Regnault's experiments, and published in 1849; and they may be regarded as practically identical with the results of those experiments.

W. J. MACQUORN RANKINE.

Glasgow, January, 1864.

A SAFETY LOCOMOTIVE FOR SHARP CURVES.

To the Editor of THE ARTIZAN.

SIR,—In your publication of December, 1863, there appeared a description of a safety locomotive for sharp curves, constructed by Mr. Cross for the St. Helen's Railway, which, from the accounts given of its performance, prove it to have been a most perfect success. It was not with a little surprise that I found, in looking more minutely into the details, that, so far from its being a novelty, it was a perfect copy of my design which you published in the ARTIZAN of May, 1857, giving it a publicity which must have brought it under the notice of most engineers. Indeed, so closely do I find my design has been copied, that nearly the very same words I used in advocating my design are again repeated by Mr. Cross. But, before proceeding further, I should explain that my motive for wishing to enter so fully into this case is, that Mr. Cross denies that the designs are the same. He does this in the *Railway Times*, in which also appeared a description of his engine, and which, in justice to myself, I was obliged to notice it. I, therefore, wrote stating that the design was mine. Mr. Cross replied that this was not the case, that the design was Mr. Bridge Adams' and patented by him. I made further inquiries and found Mr. Adams had only patented the design in 1861; and as I had published it in 1857, four years before, my claim to being the inventor was still the same, and I wrote to this effect, which brought the following reply from Mr. Cross, in the *Railway Times*, from which I will make an abstract:—

"As Mr. Strong is not satisfied with my assertion that the plan proposed by him in 1857 is essentially different from that patented by Mr. Adams, will you allow me to explain that difference, and, as far as I am concerned, to close the correspondence with thanks for your courtesy.

"Mr. Adams' axle boxes are parts of the segment of a circle, the axle being the chord, and as the axle box guide blocks are also cut to the same circle, there is nothing to prevent the lateral movement of the wheels when passing round curves, and a consequent alteration in the parallelism of the axle.

"Mr. Strong's axle boxes are parts of the sides of a triangle, the axle being the base, or, as he himself says in the ARTIZAN of 1857, the axle box guide blocks are not shown as fixed at right angles to framing, as is the case at present with engines of ordinary construction, but are fixed at an acute angle to framing and the sides of the axle boxes fitted to them, this is done to give the self-adjusting motion to the axle."

The following is an abstract from my reply to Mr. Cross, which appeared in the *Railway Times*:—

"Mr. Cross, in what he calls his explanation of the difference between my plan and Mr. Bridge Adams', so confuses (but evidently with a motive) the subject with his geometrical definitions, quite out of place, that it is necessary I should now explain, in plain words, the real merits of the case.

"The self-adjusting or radial movement of the axle which enables this engine to pass round quick curves is obtained by the simple arrangement that, instead of fixing the axle guide blocks at right angles to framing as hitherto, they are fixed at an acute angle to framing; and, play being given to the axle boxes in the guide blocks, as the engine enters into a curve, the axle boxes are forced along the guide blocks, which, being inclined planes acting as a wedge, and, using a practical term, force the axle off the square of the framing or adjusts it, or radiates it, to the curve.

"Now I claim as my invention the fixing of the guide blocks at an acute angle to framing, on which, as I have explained, the whole movement depends. Mr. Adams' design is precisely the same, he fixes his guide blocks at an acute angle to framing, but very slightly curves the surface of guide blocks, a mere matter of form, but in no way affecting the principle; and yet this is what Mr. Cross says is the essential difference. It is evident to any one who understands the subject that the designs are one and the same in action and principle."

The case you will allow is so clear, it is needless my explaining any further; but I may add, that if there is any choice in the simple form of the surface of the guide blocks, in practice the plane surface is best, being most easily repaired, and, from the unequal wearing of the axle bush, the axle box wears off the perpendicular, with the curved surface of the guide block the axle box would be apt to get locked, which would not be with a plane surface, but of course this is a mere matter of detail, the action and principle still remain the same.

I will now show that my very argument, in favour of my design, is copied. I said in May number of ARTIZAN, 1857. "We should, in the first place, show the necessity of some plan being adopted for relieving the straining and detrimental action which a locomotive has to undergo when passing round a quick curve. By those not practically acquainted with the working of locomotives, it may be thought that they pass round a curve with an easy uniform motion, this is far from being the case, as they are forced round by a series of pitches or lurches, which are the only terms we can give for this peculiar action. This is caused by the present construction of locomotives, which is that of a rigid frame placed on axles, parallel to each other, its mechanical line, therefore, being a straight line, the act of passing round a curve may be termed an unmechanical one. These pitches, or lurches, take place every 30ft. or 40ft., when the pressure of the flange of the leading wheel against the outside rail of curve becomes so great as to throw round the front end of engine, which is then relieved until it again works itself into the same position, and is again thrown round by the same excessive pressure of the leading wheel flange against outside rail of curve.

"There is also another objection to fixed parallel axles, as they limit the number of wheels which can be placed under an engine, and also limit the distance which can be obtained with safety between the centres of leading and trailing wheels to 16ft.

Mr. Cross, on the same subject, says—"Hitherto the construction of engines has only adapted them for running into a free rolling movement on straight lines, even when accurately made, and only capable of running on curves by dint of grinding or sledging friction of the wheel tyres. To diminish as much as possible the amount of this friction, the practice has been to keep the engine as short as possible, *i.e.*, the axles as close together as possible. The result has been an unsteady base and a top-heavy superstructure, liable to constant oscillations from two affecting causes—the alternate motion of the pistons in the crank and the irregularities of the rail;" and further on says—"Mr. Cross set about the construction of an engine that would be capable of running freely and without impedimental friction in a straight line, either end foremost; and also pass with a free rolling movement round curves of as sharp a curve as a radius of 132ft.

I will next show that in the lengthened wheel base, number of wheels, and placement of wheels; Mr. Cross has again copied from my design. I recommended that "locomotives on this principle could be very advantageously constructed with eight or ten wheels, the centre ones being driving wheels, and the leading and trailing self-adjusting or guiding wheels, as described." Mr. Cross has constructed his engine with eight wheels, and made the centre ones the driving wheels, and the leading and trailing the self-adjusting or guiding wheels, as described.

Mr. Cross has applied to his engine the system of securing the tyres to the wheels by elastic steel hoops, which allows the tyres to revolve on the wheels. I do not wish to enter into the merits of this plan, it being easily seen that no arrangement of this kind would of itself be a means of enabling a long engine with axles at right angles to framing to pass round a sharp curve; this can only be done by placing the axles at the required angle for describing the line of the curve, which is done by the self-adjusting axle.

I am confident that the "self-adjusting or the radial axle" for locomotives is yet to hold a most important place in railway engineering, admitting as it does of sharper curves and longer engines. I leave it to you and your readers to say if I am not entitled to the credit of having been the inventor of it.

I am, Sir, your obedient servant,

EDWARD STRONG.

Caledonian Railway, Carstairs, 23rd January, 1864.

REVIEWS AND NOTICES OF NEW BOOKS.

Pocket-book of Useful Formulæ and Memoranda for Civil and Mechanical Engineers. By GUILDFORD L. MOLESWORTH, Member of the Inst. of Civil Engineers, Principal Resident Engineer of the Ceylon Railway. Fourth edition, with Supplement. London: E. and F. N. Spon. 1863.

When noticing the first edition of Mr. Molesworth's excellent little pocket-book we expressed a highly favourable opinion of it, and predicted that it would be a great success. We were right. The significant fact of the book having gone through four editions will carry conviction as to the high estimation in which

the book is held by engineers, more thoroughly to the minds of our readers, than anything we can add to our former notices.

The supplementary matter, by Mr. J. T. Hurst, is deserving of high praise. Whenever we have occasion to seek reliable information on any of the subjects contained in Mr. Molesworth's book, we refer, by preference, to his "Useful Formulæ," and find most readily what we seek. Indeed, it is an admirable little pocket-book.

A Record of the Progress of Modern Engineering: Comprising Civil, Mechanical, Marine, Hydraulic, Railway, Bridge, and other Engineering Works, with Essays and Reviews. Edited by William Humber, Assoc. Inst. C.E., and Memb. Inst. M.E. London: E. and F. N. Spon. 1863. Part XII.

In the course of the twelvemonth during which the work before us has been published, we have noticed it several times.

Mr. Humber has now completed the first annual volume, and promises, by his previous announcements, that in future he will publish the "Record" yearly or half-yearly, instead of monthly.

The volume now completed consists of a goodly number of plates of large size, principally relating to railway bridges, roofs, station-buildings, and works of a similar character.

The Builders' and Contractors' Price Book for 1864. Revised by G. R. Burnell, C.E., and Architects. London: Lockwood and Co. 1864.

Mr. Burnell has succeeded in condensing somewhat advantageously the vast amount of information now, as heretofore, given in this annual publication. He has also made a thorough revisal of the day-work prices throughout the several trades. In detail of the prices of carpenters' and joiners' work, numerous alterations have been made to render those portions of the work correct. The prices for ironmongery, gas fittings and gas fitters' work, and for masons' work have each been revised; and, as a whole, "The Builders' and Contractors' Price Book for 1864" is a great improvement upon the publication of the previous years.

A Treatise on Sugar Machinery: "Including the process of producing sugar from the cane; refining moist and loaf sugar, home and colonial; the practical mode of designing, manufacturing, and erecting the machinery; together with rules of proportions and estimates." Illustrated by four single and twelve large folding plates. By N. P. Burgh, Engineer. London: E. and F. N. Spon. 1863.

The author deserves great credit for the excellent book he has made, it being a first attempt too.

We recognise in Mr. Burgh a skilled, practical draftsman. The illustrative plates are well got up, and the textual matter is of a very practical character.

We believe the publication of Mr. Burgh's book will serve the purpose for which it is designed.

A Practical Treatise on Limes, Hydraulic Cements, and Mortars. By Q. A. Gillmore, A.M., Brigadier-General of U.S. Volunteers, and Major of U.S. Corps of Engineers. New York: D. Van Nostrand, 192, Broadway. London: Trubner and Co. 1863.

An excellent treatise, containing the results of a considerable number of very interesting and valuable experiments.

The volume under notice is one of a series of official papers on Practical Engineering—U.S. Engineering Department (No. 9)—and it will be found of great value to the English engineer and contractor.

The Story of the Guns. By Sir J. Emerson Tennent, K.C.S., LL.D., F.R.S., &c. London: Longman, Green, Longman, Roberts, and Green. 1864.

A vast deal of interesting, scientific and general information relating to both small and large guns and their projectiles, has been collected by Sir J. E. Tennent, and presented to the public in the volume under notice. There may be very much that is true in the allegations made against the policy and the conduct pursued by the War Department in the great rifled ordnance contest; and, whilst the author evidently sets out with the intention, judging by his preface, of giving simply, but faithfully and unvarnishedly, "in the order of time and occurrence, a consecutive memoir of what has taken place since the war in the Crimea, in connection with the improvement of the rifled arms," the tone in which his book is written has, in our opinion, too much the character of advocacy of the Whitworth against the Armstrong rifled arms to satisfy a disinterested reader, who, seeking for a realization of the statements and promises made in the preface, finds that, whenever it is possible to praise Mr. Whitworth and his inventions or improvements, the author does not permit the opportunity to pass without sounding a note in praise, and may, therefore, not unfairly be taken to be a partizan.

Apart from this serious drawback, we find the book contains, perhaps, the best collection of historical notes on the progress of improvements in small arms and ordnance and their projectiles, made during the last few years, and the previous condition of those and other arms employed in military and naval warfare, and good service has been done by collecting together these useful materials—although exception may be taken to the way in which they are there turned to account. The book is well worthy of careful perusal.

NOTICES TO CORRESPONDENTS.

F. W. W.—We have been expecting to hear from you upon the subject of your previous communications.

R. E. D. (Edinburgh).—Our limited space for the present number prevents us inserting herein the replies which we have prepared in answer to your queries; they shall be given in our next. Or if you send us your address, we will communicate with you through the post.

RECENT LEGAL DECISIONS
AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

Under this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

Oxlade *v.* the North-Eastern Railway Company.—Mr. Oxlade applied for an attachment against certain directors of the North-Eastern Railway Company for not obeying an injunction obtained by him under the Railway Traffic Act, and served upon the company in 1857, enjoining them not to charge him for coal carried on their railway more than they charged other persons under similar circumstances. It appeared by Mr. Oxlade's affidavits that the company charged him 1s. more per ton than they charged persons who had a depot accommodation on the line. The Court, however, thought that it did not sufficiently appear on the affidavits that the company might have been put to more expense and trouble because Mr. Oxlade had not a depot accommodation for his coals on their line, than they were for those persons who had. On these affidavits, therefore, the rule was refused.

The Submarine Telegraph Company *v.* Dickson.—This was an action brought by the plaintiffs against the defendant, the owner of a Swedish ship, for so negligently casting his ancher when in the Channel, off the Kentish coast, that he caught, got entangled with, and damaged the plaintiff's cable. The defendant, in substance, pleaded that he was lawfully navigating the ship, more than three miles from the coast, and that he had no notice that the cable was where he had cast anchor. The plaintiffs now assigned that the defendant so negligently disentangled his anchor from the cable when he knew it was there that he damaged it. There was another replication that the soil was the Queen's, who had given him license to lay the cable there, in answer to a plea averring that the accident happened on the high seas, where the Queen had no jurisdiction, the ship being a Swedish ship. Both declarations and pleas were demurred to. The Chief Justice thought the declaration good which charged damage to the plaintiff by the negligence of the defendant. He assumed that the bottom of the sea might be used for lawful purposes as well as the surface. Of that the Court might take judicial notice, there being Acts of Parliament on the subject of submarine cables. The plaintiffs had a right to use the bottom of the sea, and to place their cable there. The defendant had a right to use the surface of the sea for the ordinary purposes of navigation, and to let go his anchor if the need of navigation required it. The two rights happened to conflict; the plaintiff's property was damaged and their right violated by the defendant breaking their cable with his anchor. The defendant said, "I had a right to let go my anchor." Then came the replication, "You might have had that right, provided you had exercised it with due care and skill; but you had no right at all to damage our property." The whole essence of the case turned on the word "negligence." If you had used due skill and care the damage would not have arisen. Mr. Justice Williams concurred. Mr. Justice Willes said, the defendant was bound to use reasonable care in so dropping his anchor as not to foul the cable. The declaration was good, the plea good, the second replication good, the third replication bad, as traversing immaterial matter.—Judgment for the plaintiff.

Parson *v.* Edwards.—The question here was on the construction of a lease of a coal mine, the point being as to allowance to the lessee for "faulty" coal. The rent was payable for coal actually worked, and allowance for faulty coal, notice being given of it. The Court decided for the plaintiff, the lessor.

Curtis *v.* Platt.—This was an appeal from a decision of Vice Chancellor Wood. The plaintiff was the assignee of a patent taken out by a person named Wain, of Oldham, in the year 1854, for improvements in the self-acting cotton-spinning mule. In 1860 a patent was granted to the defendant for certain improvements in the action of the mule, which the plaintiff alleged were merely imitations of his patent, and instituted this suit in consequence. The Vice-Chancellor held that there had been no infringement of the plaintiff's patent, and made the decision, now appealed from, in favour of the defendant. The Lord Chancellor, in dismissing the appeal, said that, in his opinion, both the patents represented combinations to effect the same end but by totally different means. The patent, therefore, of the defendant could not be considered as an infringement of the one granted to Wain, and the decision of the Court below must be affirmed.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

Blast-Furnaces in Cashmere.—At the annual supper of the clerks and foremen in the employ of Messrs. Gilkes, Wilson, Pease, and Co., Middlesbro', Mr. J. Aspinall, the chairman, said Mr. J. B. Pease, one of their employers, was then on a tour in India, and in a letter which he had recently sent to the cashier of the firm, Mr. Pease remarked that he had seen a real original furnace for the manufacture of iron at Cashmere. The height

of the furnace was 3ft., and its cubical contents 3ft. and a small fraction. The tuyeres were two in number to a furnace, and in their construction resembled a Scotch bagpipe. They were worked by the fingers, thumbs, and arms of the men. The stone was of the hematite class, not calcined before it was put into the furnace, but reduced to a powder. Charcoal was the fuel used, and the yield of a furnace was equal to 42½lbs. of iron per 24 hours, but this quantity was very crude, and lost 50 per cent. by hammering. In its manufactured state, however, it was very strong. Wages also seemed to be on a par with the dimensions of the furnaces and their yield, for the wages of furnacemen were equal to 5*d*., and of charcoal burners to 3*d*. per day.

A MAGNETIC ETHER.—In a paper recently read at the meeting of the Royal Society, the Astronomer Royal propounds a theory to account for magnetic storms. The phenomena, in Mr. Airy's opinion, represent the movements of a magnetic ether which he supposes to overspread the whole surface of the earth as an impalpable fluid envelope several feet in thickness. If we then conceive this magnetic ether "to be subject to occasional currents produced by some action or cessation of action of the sun, which currents are liable to interruptions or perversions of the same kind as those in air and water," we have a theory by which the disturbances that occur in the observed phenomena of terrestial magnetism may be explained.

SUBSTITUTE FOR GUNPOWDER.—An explosive compound, which it is proposed to use for general purposes, has been invented by Messrs. Hall and Wells, of Worcester. They take chlorate of potash, 47 parts; ferro-cyanide of potassium, 38 parts; and sulphur about 5 parts. They reduce these ingredients separately to a powder by grinding them on a suitable slab, and when properly ground it is thoroughly mixed, water being added to permit the whole to be formed into a stiff paste; after this they allow the composition thus prepared to stand, allowing the water to evaporate, and then they add ten parts of caoutchouc. These ingredients are to be thoroughly mixed, and if to be used in powder pressed and granulated, or the compound may be moulded into a suitable shape, forming a solid compact body, which would be highly advantageous in preparing charges, either for ball or blank practice, or otherwise. Although they have given the proportions that they have found with their present experience to be satisfactory, nevertheless they claim the privilege of altering or modifying the proportions according to the purposes for which the compound may be required.

IMPROVED DAVY LAMP.—Mr. P. Bourne, of Whitehaven Colliery, viewer, has invented an improved means for extinguishing the light of the lamp in the act of opening it, and before the wire gauze covering can be removed from the lamp. He attaches to the lamp near the wick-holder an apparatus consisting of one or more levers, mounted on a suitable fulcrum, and which apparatus is capable of being depressed on the wick by the act of removing the wire gauze covering. The apparatus is, by the action of a suitable spring or springs, or by the weight of the short end of the lever or levers, or by both of such means, kept out of the way of the ignited wick so long as the gauze covering remains on the lamp, or when the gauze covering is being placed on the lamp; but as soon as any attempt is made to remove the gauze covering one or more small projecting pieces attached to the mounting of the gauze covering is forced under the short arm of the lever, by which the other end of the lever is depressed on the wick, and the light becomes extinguished.

AN EXPLOSION AT THE CITY GAS WORKS, Whitefriars, recently took place. At the inquest Mr. Mann, superintendent of the works, said that the hydraulic room was a well by the side of the gas-holder. The gas-pipes passed through the well for the purpose of entering the gas-holder. There was generally water at the bottom of the well. The well was covered with iron. There were two doors at the top of the well for the purpose of enabling the well to be examined. The gas-pipes were obliged to be covered with water before they entered the gas-holder. The well doors were always kept closed to prevent the entrance of air. After the explosion the doors were found to have been blown open. There was a pump down into the well. In the opinion of witness the explosion was caused by the mixture of gas with atmospheric air in the well. He had made inquiries and could not find that any one was in the well that day. In his opinion there was no leak in the well. The top of the well was used as a thoroughfare. For some days previous to the explosion a pail containing burning coke had been kept at a distance of 4ft. 6in. from the pump down into the well, and it was so placed because the pump was frozen. He did not think that any of the lighted coke had come in contact with the gas in the well.

THE THAMES EMBANKMENT COMMITTEE have decided upon using stone from quarries in Lundy Island, which will be unshipped at Highbridge, and taken to London over the Central Somerset and Dorset Railway.

FRAUDULENT TRADE MARKS.—On the 1st of January last, an important Act of Parliament, the "Merchandise Marks Act," came into practical operation for the first time. It makes it a misdemeanour to counterfeit any trade mark, or falsely to apply any such trade mark with intent to defraud, whatever the article to which it may be applied, whether it be a cask, bottle, stopper, case, cover, wrapper, band, ticket, label, or any other thing in or with which any commodity is sold, or intended to be sold. Again, it is from henceforth an offence for any one to sell or expose articles with false trade marks attached, the penalty being the forfeiture of a sum equal to the value of such articles, and a fine besides, not exceeding £5 nor less than 10*s*. Every alteration and imitation of any trade mark, made with intent to defraud, are to be deemed forgeries, and punishable as such. It is made obligatory on every person who shall sell an article having a false trade mark to give information as to where he procured it; and power is given to the justices of the peace to summon parties refusing or neglecting to afford such information, and to impose a penalty of £5. Further, to mark any false indication of quantity, is made punishable by a penalty equal to value of the article, and a fine not exceeding £5, and not less than 10*s*. This provision will apply, among other cases, to the familiar instances of pale ale sold in bottles, and of cotton reels and the like. The punishment on conviction of any offence which by the Act is made a misdemeanour, is to be imprisonment for not more than two years, with or without hard labour, or by fine, or both, and also by imprisonment until the fine shall have been paid. The time within which any proceeding may be commenced is limited to three years after the commission of the offence, or one year after its first discovery by the person proceeding. There is a clause according to which the vender of an article with a trade mark is to be deemed to warrant or contract with the purchaser that the mark is genuine, unless the contrary shall be expressed in writing by the vendor, and delivered to the purchaser, and this applies also to the indication of quantity. A plaintiff suing for a penalty may be compelled to give security for costs, and a defendent, in case of judgment going in his favour, is to have a full indemnity for costs.

COMMERCIAL DOCKS AND GRAND SURREY DOCKS AND CANAL BILL.—A deputation upon this bill had an interview with the Right Hon. Thomas Milner Gibson, on the 26th ult., at the office of the Board of Trade, Whitehall. The deputation was introduced by Mr. Goschen, M.P.; and consisted of Mr. Tottie, chairman of the Commercial Dock Company; Mr. J. Mews, deputy chairman; Mr. Robert Carter, director; Mr. A. Boyson, deputy chairman of the Grand Surrey Docks and Canal Company; Mr. Chas. Churchill, director; Mr. J. Griffin and Mr. G. W. Heisch, secretaries; Mr. J. R. M'Clean, engineer; Mr. A. D. Druice and Mr. W. Gibson, solicitors; and Mr. John Newall, parliamentary agent.

THE GREAT EASTERN was recently put up for sale by auction at Liverpool, by order of the mortgagees. A bidding of £50,000 was made, and no advance being made, Mr. Cunard, the auctioneer, said to save the time of the gentlemen present he should put in the owners' bid, always the most disagreeable bid an auctioneer could put. He then said the reserve bid of the owners was £130,000. It was understood that the sum would be sufficient to pay off all judgment claims against her. No advance was made on the reserve bid, and the ship was withdrawn.

CONSUMPTION OF PAPER.—From the last trade returns it appears that the consumption of foreign paper in England is considerably on the increase, 112,503cwts. having been imported in the first eleven months of last year against 92,288cwts. in the corresponding period in 1862. Belgium supplies the largest quantity—no less than 61,950cwts. out of the 112,503cwts., having come from that country. In the eleven months ending November, 34,746 tons of rags used in the manufacture of paper reached the English market from abroad.

TRIAL OF A STEAM FIRE ENGINE.—A trial of one of Messrs. Shand, Mason, and Co.'s small patent vertical steam fire engines, took place recently at the London Docks. Steam was got up to 50lb. from cold water, in 8min. 5sec. The engine started with that pressure with $\frac{3}{4}$ in. jet, steam 50lb., water 40lb.; and was then changed to $\frac{7}{8}$in. jet, steam 90lb., water 60lb.; then changed to 1in. jet, steam 100lb., water 60lb.; then changed to 15-16th-in. jet, steam 85lb., water 80lb.; and then changed to two jets at one time, $\frac{5}{8}$in. and $\frac{3}{4}$in., steam 100lb., water 60lb. All these changes were made without stopping the engine. It then worked through 3 jets, two of $\frac{1}{2}$in., and one $\frac{5}{8}$in., in diameter, the steam 80lb., water 60lb. With 15-16th-in. jet, to throw over a shed 80ft. distance through 120ft. of hose the steam stood at 100lb., and the water at 90lb. The 15-16th-in. jet was thrown over one of the large warehouses which was 68ft. from the parapet to the ground to about 40ft. above the parapet, through 160ft. of hose. In all these experiments the engine was placed on the quay, and drew, at once, from a depth of 20ft. from the suction of engine to surface of the water.

THE LARGE MACHINERY AND IRON BUSINESS OF MESSRS. FAIRBAIRN AND CO., of Manchester, is about to be merged into a joint-stock establishment, to be called the Fairbairn Engineering Company, with a capital of £250,000, in shares of £10, of which the chairman, Mr. Thomas Fairbairn, the sole representative of the firm, subscribes for £70,000, a considerable portion of the remainder being likewise already taken. Possession is to be assumed on the 31st of March, and the present manager of the establishment will continue its superintendence.

THE TRADE OF THE NORTH-EASTERN PORTS.—The North-Eastern Railway Company are greatly extending their import traffic in the Tyne Dock. The company is busy with a large corn warehouse intended to be seven storeys in height, to accommodate the grain and other trades from the Baltic. They also despatch quantities of Swedish iron from this dock to Sheffield, and have recently introduced a new article of import into the Tyne. Considerable numbers of colliers take out coke to Carthagena, and for return cargoes many of them have been recently employed in bringing to the Tyne Docks, Esparto fibre, or Spanish grass, which is being employed in paper-making. The North-Eastern Railway despatch this new article of commerce to the paper manufacturers of Lancashire, the midland districts, and to Scotland. During the year 1863, 171 vessels of 70,140 register tons, averaging 410 tons each, were built at Sunderland. This is the highest number since 1840, and the tonnage is greater than that of any previous year from 1835. Of the 171 vessels built last year in the Wear, 24 of the number were of iron, with an aggregate tonnage of 17,719 and an average of 738 tons. Within the past three years, however, the Tyne has taken the lead of all the northern rivers in iron ship-building. The amount of iron tonnage launched upon that river was very large last year, and the building yards there are all well employed; one of the leading firms has orders in hand to keep the works going for more than twelve months at full work.

TUNNEL UNDER LAKE MICHIGAN.—A contract for the construction of a tunnel, extending some two miles under Lake Michigan, at Chicago, for the purpose of supplying the city with pure water, has been awarded; the lowest bid for completing the same being 315,130 dollars. The contract is for a tunnel of 5ft. internal diameter, lined with brick. The tunnel is to be excavated 35ft. below the bed of the lake, and to have 4ft. of dip landward. Strainers will be fixed over the outlet to keep out the fish. The total area of the tunnel will be nearly 20 square feet, an area amply large enough to furnish water continuously to a city five or six times the size of Chicago in the present day.

ELECTION OF SURVEYOR TO THE BIRKENHEAD COMMISSIONERS.—The road and improvement committee of the Birkenhead commission have appointed Mr. T. C. Thorburn, C.E., at present surveyor to the borough of Derby, to be surveyor to the Birkenhead commissioners, at a salary of £500 a year.

EXPLOSION OF GUNPOWDER AT LIVERPOOL.—A heavy explosion took place at Liverpool on the evening of the 15th ult., when the *Lottie Sleigh*, with about 6 tons of powder, blew up in the river. This vessel was taking in powder from the magazine boats off Tranmere about 6 p.m., as the steward was in the cabin triming the lamps with paraffin oil, some of it exploded and ignited the bed-curtains. Prompt measures were taken to suppress the flames, but they had already obtained the mastery, and the knowledge that so much gunpowder was on board doubtless, to some extent, paralysed the exertions of the crew. At length, despairing of success, they gathered together whatever they could lay their hands on, and were taken off by a passing Rock ferry-boat, the explosion occurring about half-past seven.

AN ACCIDENT AT WOOLWICH DOCKYARD, causing the death of three men, occurred on the 11th ult. The paddle steam vessel *Spiteful*, lying in the inner basin, having been condemned, arrangements had been made to remove her boilers, &c., by the powerful crane and shears on the wharf, which is worked by hydraulic pressure. A number of artisans and labourers from the steam factory were employed on board the *Spiteful* to carry out this work, and one of the boilers having been attached to the gear was lifted from its position, and had just cleared the hold of the ship, when a link of the chain attached to the shears snapped asunder, and the shears, being thus released, canted round with the ponderous gear attached, sweeping with great force over the deck on which the men were standing, by which they were knocked about in all directions, the heavy chain and gear falling upon them, causing the above loss of life.

THE STREET TRAFFIC OF LONDON.—Various expedidents have been proposed for relieving the pressure of the street traffic of the City of London—among the more important of which are new railways, new police regulations, and new streets. The difficulty of satisfactorily solving this problem will be obvious from a mere statement of the facts of the case. On every business day in London upwards of 700,000 persons enter the City by its various approaches, and leave it again in the evening for their homes at the West-end, in the suburbs, or in the country. 700,000 persons represent a population equal to the whole inhabitants of South Wales, or of the city of Manchester. Drawn up in a line, two deep, standing close together, they would occupy an extent of over 120 miles; and, ranged six deep, they would take more than twelve hours to march past a spectator at the rate of 110 paces a minute. Of the 700,000 persons and upwards entering and leaving the City daily (exclusive of those entering the West-end and other parts of London), it was ascertained by the officers of the City-police, in the month of May, 1860, that an average of 535,000 proceeded on foot, and 171,000 in vehicles, making a total of 706,000 persons. The number of vehicles ascertained at the same time to enter the City every 24 hours was 57,765, which, if drawn up close in line, would occupy a length of about 260 miles, reaching from London to York, and extending more than 50 miles beyond the latter place. The closeness with which the vehicles follow each other in the

streets may be inferred from the fact that between ten and eleven a.m. on Wednesday, the 19th of November, 1862, it was ascertained that the total number passing Bow Church, in both directions, was 1,255, of which 348 were omnibuses, 584 cabs, and 282 carts, drays, vans, and waggons, besides 41 trucks and barrows. The numbers and proportions of vehicles passing the same place between four and five p.m. on the same day were ascertained to be as nearly as possible the same.

Engineering Factories in Italy.—Genoa has four foundries and mechanical establishment. The first, which is regarded as the most important metallurgical establishment of Italy, is managed by Messrs. Orlando Brothers, and has been at work since 1848, when it was formed with a concession from the Government. The works employ 700 persons, and consume annually nearly 1800 tons of pig iron and fuel. Most of the good workmen and foremen of Upper Italy receive their mechanical training there, the works producing every description of manufacture, such as rails, pipes, steam boilers, &c. Fifty locomotives for the railways of the old Sardinian and Tuscan States were supplied from this establishment, and it is expected that the number of men employed will soon be increased from 700 to 1000, as Messrs. Orlando, intending to undertake the construction of ships of war for the State, have just made very extensive arrangements with that object. The foundry of Messrs. Balleydier, which occupies 350 men, has an annual consumption of 1000 tons of pig iron and combustible. The works of Mr. Robertson, again, employ 300 men, and consume annually 900 tons of material. The fourth establishment was only brought into operation in 1860, by Signor Migoue, a Genoese. At present it employs only thirty workmen, and its annual consumption of materials is limited to 30 tons.

NAVAL ENGINEERING.

The Screw Steam Sloop "Fawn," 17 guns, 751 tons, 100 horse-power, on the 14th ult. underwent a trial of her machinery at the measured mile off Maplin Sands. The following were the results:—Average speed at full boiler power, 8·578 knots; revolutions of engines, *maximum*, 94; mean, 91·8; pressure of steam, 20; load on safety valve, 20; vacuum, 26; speed at half-boiler power, 6·830 knots; revolutions, *maximum*, 71; mean, 64·5. The vessel went round the circle at full boiler power, helm at an angle of 37 deg. port, in 4min. 28sec.; revolutions, 77; diameter of circle, 228 yards; at half-boiler power, helm starboard, 35·5 deg., in 5min. 31sec.; revolutions, 63; diameter, 254 yards. She is fitted with a common propeller, with leading corners cut off; diameter, 10ft.; pitch, 12ft.; length, 2ft.; immersion, 8in.; draught of water, 13ft. 7in. forward, 14ft. 4in. aft. There was no wind, and the sea smooth. The vessel was full-rigged and had six months' stores on board. The trial was considered very satisfactory.

The "Lord Warden."—The construction of the *Lord Warden* will differ in several very important particulars from that of the *Royal Oak* and the other wooden armour-plated frigates already completed, the effect of which will be to render her very little inferior in strength and solidity and shot-resisting power to the most recently-constructed of our fleet of iron-clads. In the squadron of armour-plated vessels recently built the $4\frac{1}{2}$in. armour-plates are bolted to 18in. of teak planking, fastened to the oak timbers, which are in turn held together by the longitudinals and tie-irons which traverse the ship from stem to stern. This construction is objectionable on several grounds, not the least of which arises from the absence of a resisting medium between the teak planking and the interior of the vessel to prevent the flying off of splinters, which experience has shown are invariably more disastrous in their effects on shipboard than the passage of either a shot or shell through the ship's sides. This important fact has not been lost sight of in the construction of the *Lord Warden*, and it is accordingly intended to place an iron skin, formed of plates $1\frac{1}{2}$in. in thickness, between her timber ribs and teak planking, on which again will be placed her $5\frac{1}{2}$in. and $4\frac{1}{2}$in. armour-plates. The after portion of the keel has been got in its place on the blocks beneath the shed where the *Lord Warden* is building; but, in consequence of the greater number of the dockyard mechanics being employed on the *Achilles*, only a comparatively small number are at work on the new frigate. In a short time, however, at least 1,000 workmen will be transferred to the *Lord Warden*, in the completion of which every exertion will be used. Some alterations have been made in the size of the vessel since the order for her construction was received from the Admiralty, and the following will be her exact dimensions:—Length between perpendiculars, 280ft.; length of keel for tonnage, 233ft. $11\frac{3}{4}$in.; extreme breadth, 58ft. 9in.; breadth for tonnage, 57ft. 2in.; breadth moulded, 56ft. 4in.; depth in hold, 20ft. 9in.; burden, 4,067 26-94ths ton.

The "Wizard," screw steam gunboat, 60 horse-power, attached to the first division of the Sheerness steam reserve squadron, was taken out from Sheerness harbour for a preliminary trial of her machinery, &c., at the measured mile off Maplin Sands, on the 7th ult., previous to being commissioned for service on the West Coast of Africa. An average speed of eight knots an hour was attained, and the trial was considered altogether very satisfactory.

The "Lyra," 9 guns, 60 horse-power, screw corvette, made her final trial of speed, preparatory to sailing on foreign service, on the 9th ult., at the measured mile in Stokes Bay, under the superintendence of the officers of the Steam Reserve and steam factory, realising a speed of $7\frac{1}{2}$ knots.

The Iron Masts of the "Achilles" were successfully fitted on the 6th ult., by means of the massive floating sheers, which were towed down from the dockyard to Gillingham Reach for that purpose. The iron masts are the largest ever constructed for a vessel of war, and were manufactured at the Bridge Works, Chepstow, by Messrs. Finch and Heath. The *Achilles* will be the first vessel in the British Navy to carry four masts; but even with this advantage each of her masts will be 100ft. apart. Experience has shown that iron masts last much longer than wooden, that they are lighter and stronger, serve as valuable ventilators, and are also better conductors of electricity. If they are shot away and fall overboard they will immediately sink, instead of floating alongside and fouling the screw, as is the case with wooden masts. The mainmast of the *Achilles* weighs no less than 21 tons 12cwt.; its length being 121ft. 9in., diameter 3ft. 4in., and length of head from hounds 20ft. The weight of the second foremast is 19 tons 2cwt., its length 103ft., diameter 3ft. 4in., and length of head from hounds 20ft. The foremast weighs 15 tons 18cwt., its entire length 103ft. 10in., diameter 2ft. 8in., and length of head from hounds, 13ft. The mizenmast is 84ft. in length, its weight 8 tons 12 cwt., diameter 26in., and length of head from hounds, 13ft. The diameter of the main and second fore masts at the head is 30in. in each, that of the foremast 24in., and of the mizenmast $19\frac{1}{2}$in. Each mast is formed of three curved plates half an inch in thickness, which form the skin, or outside shell of each, the joint where the vertical edges of the plates meet being so formed that the outsides of the masts show no ridges. Under each of the vertical joints three strong tie-irons are placed, to which are riveted the plates forming the mast, the rivets on the outside being counter-sunk, or let in flush, the exterior of the mast consequently presenting a round and perfectly smooth surface. The masts are parallel from the heel to the hounds, where a horizontal plate is introduced which is made to carry the top, and this plate facilitates the reduction of the size of the mast from the hounds to the cap. Where the shrouds pass over the masts the plates are double to resist the extra strain and wear.

State of the Navy.—The official annual return of the number, name, tonnage, station, and every particular regarding the steam and sailing ships composing the British Navy, together with the horse-power and armament of each has been made. The total strength of the effective ships of the navy on the 1st of January last was 975 of all classes, not including a number doing duty in the various harbours, both at home and abroad, the whole of which would be speedily converted into block ships for the defence of the coast, together with a numerous fleet of iron and wooden mortar boats laid up at Chatham. Of this number, there are 72 vessels ranking as line of battle ships, each mounting from 74 guns to 121 guns; 42 vessels of from 60 guns to 74 guns each; 94 steamers and other ships, carrying an armament of from 22 guns to 46 guns each, and the majority of which are of a size and tonnage equivalent to line of battle ships; 25 screw corvettes, each carrying 21 guns; and 500 vessels of all classes, including iron ships of great power and tonnage, carrying an armament of from 4 to 21 guns each. Exclusive of the above, there is a squadron of 185 screw gunboats, each mounting two Armstrong guns, and nearly the whole of which are fitted with high-pressure engines, each of 60 horse-power. The total number of ships of all classes in commission and serving in nearly every part of the world is upwards of 300, the remainder being attached to the reserve squadrons at the various naval ports, and partially equipped, in readiness to proceed to sea whenever their services may be required. During the past year the following vessels have been completed and launched at the several dockyards, viz.:—The *Achilles*, iron-clad, 35, 6,080 tons, 1,250 horse-power; and the *Salamis*, 4, 835 tons, 250 horse-power, paddle-wheel steamer, at Chatham; the *Ocean*, 35, 4,045 tons, 1,000 horse-power, armour-plated frigate, at Devonport; the *Research*, iron-cased ship, 4, 1,253 tons, and 200 horse-power, at Pembroke; the *Minotaur*, iron-clad, 50, 6,621 tons, 1,350 horse-power, at Blackwall; the *Hector*, 32, iron-clad, 4,063 tons, 800 horse-power, at Glasgow; the *Valiant*, 34, iron-clad, 4,063 tons, 800 horse-power; and the *Tamar*, 3, 2,812 tons, 500 horse-power, iron troopship, at Millwall; and the *Wolverine*, 21, screw corvette, 1,702 tons, 400 horse-power, at Woolwich. During the same period, the following vessels, the whole of which are either of iron or iron-cased, have been commenced at the several dockyards:—viz., the *Lord Warden*, 36, 4,067 tons, 1,000 horse-power, and the *Bellerophon*, at Chatham; the *Lord Clyde*, 36, 4,067 tons, 1,000 horse-power, at Pembroke; and the *Pallas*, 6, 2,372 tons, 600 horse-power, at Woolwich. The iron-clads now building for the Admiralty, in addition to those above enumerated, are—the *Northumberland*, 50, 6,621 tons, 1,250 horse-power, at Millwall; the *Agincourt*, 50, 6,621 tons, 1,250 horse-power, at Birkenhead; the *Royal Alfred*, 35, 4,045 tons, 800 horse-power, at Portsmouth; the *Zealous*, 20, 3,716 tons, 800 horse-power, at Pembroke; and the *Favourite*, 8, iron-cased corvette, 2,186 tons, and 400 horse-power, at Deptford, together with the iron-cased shield ship *Enterprise*, 4,990 tons, and 160 horse-power, building at Deptford; and the *Royal Sovereign*, 3,963 tons, and 800 horse-power, which is being converted into an iron-cased cupola ship, at Portsmouth. The vessels now on the stocks at the various Royal dockyards, exclusive of the iron and iron-cased ships, are the *Bulwark*, 91, 3,716 tons, 800 horse-power; the *Belvidera*, 51, 3,627 tons, 600 horse-power; the *Menai*, 22, 1,857 tons; the *Reindeer*, 17, 951 tons, 200 horse-power; and the *Myrmidon*, 4,695 tons, 200 horse-power, at Chatham; the *Dryad*, 51, 3,027 tons, 600 horse-power; the *Harlequin*, 6,950 tons, 200 horse-power; and the *Helicon*, 4, 835 tons, at Portsmouth; the *Dartmouth*, 36, 2,478 tons, 500 horse-power; the *Repulse*, 89, 3,716 tons, 800 horse-power; and the *Sylvia*, 4, 695 tons, 200 horse-power, at Woolwich; the *Robust*, 89, 3,716 tons, 800 horse-power; the *Ister*, 36, 3,027 tons, 500 horse-power; and the *Bittern*, 4, 669 tons, 150 horse-power, at Devonport; the *Endymion*, 36, 2,478 tons, 500 horse-power, at Deptford; the *North Star*, 22, 1,623 tons, 430 horse-power, at Sheerness; the *Tweed*, 51, 3,027 tons, 600 horse-power; the *Trent*, 6, 950 tons, 200 horse-power; the *Newport*, 5,425 tons, 800 horse-power; the *Nassau*, 4, 695 tons, 200 horse-power; and the *Tartarus*, 4, 695 tons, 200 horse-power, at Pembroke; and the *Prince Albert*, 5, 2,529 tons, 500 horse-power, iron-cased cupola ship, at Millwall. The names of the following vessels, ordered by the Admiralty to be built at the several dockyards, have been removed from the *Navy List*:—The *Circassian*, 4, 669 tons, 150 horse-power, and the *Sappho*, 6, 950 tons, 150 horse-power, ordered to be built at Deptford; the *Alligator*, 22, 1,857 tons, 400 horse-power, at Woolwich; and the *Guernsey*, 4, 695 tons, 200 horse-power, at Pembroke. In addition to the above vessels there is a squadron of screw gun-boats in course of construction at Portsmouth dockyard.

Iron-clad Vessels.—On this important subject Admiral Paris, of the French navy has addressed to the Academy of Sciences a paper, in which he shows that iron-clad vessels have succeeded perfectly in still waters, but not so in a heavy sea, owing to the violent motion to which they are exposed, which causes them to roll more than vessels built on the old model. In consequence of this, instead of having their upper tiers at a safe distance from the action of the waves, their main force is situated at a very small elevation from the water line, six feet at the utmost. Hence it does not require a very heavy sea to render the closing of the port-holes necessary; and, what is worse, every five or six seconds the rolling exposes the parts which are not protected by armour. It is therefore not surprising that these serious drawbacks should recal to mind the old models which were less subject to heaving and rolling than the present models. The old ones, instead of presenting circular vertical sections cut horizontally by a rectangular plane, usually repeated the same curves below water that they had above. A raft assumes a horizontal position of its own accord, but on the other hand it yields to every impulse of the waves; but a barrel floating on the water will rise and fall, always preserving the same angle. The latter is the case of the old models; then why have they been abandoned? Because, although advantageous in other respects, they had the inconvenience of requiring much ballast. At present the engine and boiler are a permanent ballast, and there is no longer any fear of capsizing with three small sails. An iron-clad vessel requires little working; with engines of 4,000 horse-power boarding a vessel becomes impossible, and three light masts may be easily kept. But it is most important that the ship should roll as little as possible. To arrive at this desirable result, Admiral Paris, after a mature examination of the form and dimensions of all the old models, has selected the Royal Louis, built by Ollivier in 1740, for his type, but with some modifications, increasing the weight of the vessel from 4,730 tons to 7,500, which exceeds the weight of the iron-clad frigate Couronne by 1,200 tons. The keel he has made horizontal, like those of the best packet-boats, instead of making it 4ft. deeper aft as in most men of war. He adopts twin screw-propellers, whereby he diminishes the effort of each, and secures the advantage of working with one, in case the other should chance to become unserviceable.

The Condensers and Cylinders for the Iron Frigate "Achilles," 35, 1,250 horse-power, fitting at Chatham, have arrived at the dockyard from the establishment of Messrs. John Penn and Sons, the firm employed to supply the engines and machinery for the *Achilles*. The cylinders are the largest ever constructed for a vessel of war, each weighing between 29 and 30 tons. The two condensers weigh 23 tons 5cwt. each, and the 10 boilers nearly 22 tons each. The whole of the heavy portions of the machinery has been shipped on board without accident of any kind by means of the floating masting sheers, which have been towed down to Gillingham for that purpose.

The "Alberta," new paddlewheel steam yacht, built for the use of Her Majesty, recently underwent a trial of her speed at the measured mile in Stokes Bay, under the superintendence of Capt. H. Broadhead. On arriving at the measured mile the yacht was turned to an even keel at 7ft. draught of water, and made two circles—first, with helm at starboard, in 2min. 44sec.; the other, with the helm at port, in 2min. 44sec.; She proceeded to run the measured mile and made two runs, realising an average speed of 15·25 knots, when her port paddlewheel became defective, and she was obliged to return into harbour. The engines of the *Alberta*, 160 horse-power nominal, are from Messrs. Penn and Sons, who were represented at the trial by Mr. Matthews On the 14th ult. the *Alberta*, the necessary repairs and strengthening of her wheels having been completed, and the tide serving for the purpose, completed her trials, under the superintendence of the port officials, preparatory to being pronounced ready for the service of Her Majesty. At 12.30 p.m. she steamed out of the harbour, the weather being very thick at the time, and creating most serious doubts whether the trial could take place. On reaching the trial ground in Stokes Bay the marks on shore could barely be

distinguished, but soon afterwards the atmosphere clearing a little, the yacht was at once put on the "mile," and six runs at full boiler power obtained, with the following results:—

No. of run.	Time. min. sec.	Speed of Ship. Knots.	Steam. lb.	Vacuum.	Revolutions. of Engines.
1	3 49	15·721	27	27½	49
2	4 16	14·063	28	26½	47
3	3 48	15·789	28	27½	49
4	4 7	14·575	28	27½	49
5	3 41	15·289	28	27½	49½
6	4 10	14·400	28	29½	49

The first mean speed of these runs was, in knots, 14·892, 14·926, 15·182, 15·432, and 15·344; the second means were, 14·909, 15·054, 15·307, and 15·388. The mean speed of the yacht at full power, with and against the tide and wind, was exactly 15·164 knots. At half-boiler power, so far as could be managed by shutting off half the boilers, the following results were obtained:—First run, 3min. 45sec.; speed, 16 knots; second run, run, 4min. 43sec.; speed, 12·721 knots; third run, 3min. 49sec.; speed, 15·720 knots; fourth run, 4min. 49sec.; speed, 12·631 knots. The first means of these give 14·360 knots, 14·221 knots, and 14·176 knots; second means, 14·291 knots and 14·148 knots; and mean of means, 14·219 knots. In making the circles the results were as follows:—With full power, starboard helm, half circle, 1min. 26sec.; full ditto, 2min. 58sec.; port helm, half circle, 1min. 28sec.; full ditto, 2min. 30sec. The angle of the rudder was in both instances 24½ degrees. With half-boiler power the circles were made with the results as follows:—Starboard helm, half circle, 1min. 59sec.; full ditto, 3 min. 10 sec. Port helm, half circle, 1min. 37sec.; full ditto, 3min. 3sec. The helm in both cases had an angle of 25½deg. The machinery worked admirably. On the 19th ult. the trial of the *Alberta* was resumed. She was trimmed at an equal draught forward and aft, or "on an even keel," and this at a draught at starting of 6ft. 10½in. This gave the ship a less average draught of water, and consequently considerably less displacement than on the last trial, and had therefore an important bearing in relation to the ship's speed and her behaviour under steam, and especially so at full power. On reaching the measured mile, a pair of runs were taken with full-boiler power with the following results:—

	Time. min. sec.	Speed. Knots.	Revolutions of. Engines.
First run	3 58	15·126	49
Second run	3 44	16·071	49

Steam, 27lb.; vacuum, 26½.

The mean of the two runs gave the ship a speed of 15·598 knots against 15·164 knots obtained with full-boiler power on the previous trial. These two runs were deemed sufficient with full power, and the ship was then run off the mile ground and through Spithead, to give time for blowing the water out of the two after boilers, and trying her next over the mile with her two forward boilers, or half-boiler power. In trying the yacht with half-boiler power on the last occasion it was done in the ordinary manner—simply by shutting off one-half the boilers. By, however, getting rid of the water altogether from the two boilers cut off, the yacht got rid of so much weight, and the result of this measure was that on the required amount of ballast having been shifted from forward to aft to still keep the vessel on an even keel the ship's draught of water was reduced from 6ft. 10½in. to 6ft. 8in. Under these conditions a pair of runs were taken over the mile with these results.—

	Time. min. sec.	Speed. Knots.	Revolutions of Engines.
First run	4 22	13·740	41½
Second run	4 0	15·000	41

Ship's mean speed of the two runs 14·370 knots against 14·244 knots on Thursday. The machinery of the yacht during the trial was everything that could be required. The diameter of the cylinders are 48½in., with a 4ft. stroke, and the engines in their general plan are similar to those of the Royal yacht *Victoria and Albert*, which were manufactured by the same firm. The wheels have feathering floats, with a diameter of 14ft. 9in. at the axis. The weather was exceedingly favourable for the trial, the water being smooth, with the wind at a force of about 3 from S.W.

VENTILATION OF SHIPS IN THE NAVY.—An important part of Dr. Edmonds's ventilating apparatus has been fitted to the *Royal Sovereign* cupola-ship, at Portsmouth, in which, by a simple arrangement, from 300 to 350 natural channels actually existing in every large ship have been made available for the ventilation of the ship's bilges and the timber spaces. This is done by connecting these latter into a long air-shaft on each side of the ship, through which a draught is created by communicating it by a cross shaft into the funnel. The efficacy of this plan has been already tested in the *Royal Sovereign*, a very slight increase of temperature in the funnel sufficing to draw a current of air through the air-shafts, and necessarily through the whole frame-work of the ship, from the bilges, and which current, passing into the funnel, is carried high into the open air. This mode of ventilation promises to prevent dry-rot, by the free circulation of air which it creates over the interior timber surfaces.

TRIAL TRIP OF THE GOLCONDA.—This screw steam-vessel, recently completed for the Peninsular and Oriental Company, has made her trial trip in Stokes Bay. There was a strong breeze from the south-west. The first run over the measured mile was accomplished in 4min. 34sec., or at the rate of 13·235 knots an hour; the second run, 5min. 4sec., giving 11·842 knots an hour; third run, 4min. 46sec., 12,587 knots per hour; fourth run, 4min. 52sec., 12·329 knots per hour. The mean speed was therefore taken as 12·356 knots an hour. The engines of the Golconda were manufactured by Messrs. Humphrey and Tennant, Deptford, and the nominal horse-power being 400, indicated on trial 2,100; average revolutions, 70. The following are the dimensions of the vessel: Length between perpendiculars, 295ft.; extreme breadth, 38ft.; depth of hold, 29ft.; tonnage, 2,090 68-94ths; draught on trial trip, 19ft.; area of mid-section, 573·4ft. The Golconda was built by the Thames Iron Works and Ship-building Company, Blackwall, having been designed by the Peninsular and Oriental Company's naval architect, Geo. C. Mackrow.

THE IRON PADDLEWHEEL STEAMER "RECRUIT," 6 guns, 150 horse-power (nominal), having completed the alterations to her engines and machinery, was on the 21st ult. taken out of Chatham Harbour to the Nore, for the purpose of testing her rate of speed at the measured mile, Maplin Sands. On the occasion of the *Recruit* being taken on her last trial trip she attained a maximum speed of only about four or five knots an hour, and the paddlewheel floats were at the same time so deeply immersed in the water that it was considered useless to attempt to continue the trials. Since this trial the *Recruit* has been very considerably lightened by the removal of some of her heavy stores, together with two of her 32-pounder 56cwt. guns. With 90 tons of coals in her bunkers at starting, together with about 120 tons of machinery and boilers, 40 tons of water, and about 30 tons of anchors, cables, &c., the *Recruit* drew 8ft. 4in. aft. and 8ft. 2in. forward. On reaching the trial ground, six runs were made over the measured mile with the following results:—First run, time 5min. 35sec., speed in knots 10·746, number of revolutions 33; second run, 6min. 20sec., speed 9.474 knots, number of revolutions, 33; third run, 5min. 20sec., speed 11·25 knots, number of revolutions 32½; fourth run, time 7min.; speed 8·571 knots, number of revolutions 32; fifth run, time 5min. 1sec., speed 11·96 knots, number of revolutions 32; last run, time 7min. 2sec., speed 8·531 knots, and number of revolutions 32½. From these figures it appears that the mean average speed of the *Recruit*, with her coals, stores, &c., on board, is 10·176 knots per hour. The mean pressure of steam was 22lb., and the vacuum 25. The temperature on deck was 44 deg., in the engine-room 96 deg. The weather was favourable for the trial, there being a slight breeze from the southward with a force of 3. At the close of the official runs at full steam a couple of runs were taken with two of the boilers cut off, when the first mile was run in 5min. 38sec., equal to a speed of 10·651 knots, and the second mile in 9min. 42sec., giving a speed equal to 6·186 knots. The average speed at half-boiler power was 8·418 knots, with 26 revolutions of the engines and 26lb. of steam. The *Recruit* is fitted with a rudder at both stem and stern, which thus enables her to be steered in either direction. Some trials were accordingly made to ascertain her capabilities of making a circle when both rudders were brought into play. Each helm was accordingly brought over to an angle of 40 deg. by two men; when at half-speed, and the helms hard a-port, the complete circle was turned in a diameter of rather less than 200 yards, in 3min. 20sec.

NAVAL APPOINTMENTS.—The following appointments have taken place since our last:—E. Taylor, Engineer, to the *Blenheim*, for the Tenders; W. H. Elliott, Engineer, to the *Indus*, for the *Partridge*; N. Farraut, confirmed as Engineer in the *Cumberland*; F. J. Fairclough, Assist. Engineer, to the *Orontes*; T. Burnes, Assist. Engineer, to the *Tamar*; A. M. Brumage, Assist. Engineer, to the *Asia*, as supernumerary; J. Clark, Engineer, to the *Indus*, for hospital treatment; J. Coade, Chief Engineer, to the *Fisgard*, for the *Mutine*; A. Shoolbread, Assist. Engineer, to the *Tamar*: W. Walker, of the *Triton*, T. Cape, of the *Esk*, M. Hawkins, of the *Cumberland*, H. Darrol, of the *Royal Oak*, T. Jones, of the *Dasher*, R. H. Horne, of the *Asia*, and H. S. Pemberton, of the *Edgar*, promoted to be First-class Assist. Engineers; J. Hook, of the *Bacchante*, G. A. C. Beucke, of the *Grappler*, W. H. Smith, of the *Bacchante*, W. A. Stewart, of the *Ariadne*, and G. J. Barber, of the *Immortalité*, promoted to be Acting First-class Assist. Engineers; E. O. Crichton, Chief Engineer, to the *Duncan*; G. Mills, Engineer, to the *Asia*, for the *Albacore*; E. Brown, Engineer, to the *Duncan*, R. Highet, supernumerary in the *Asia*, promoted to First-class Assist. Engineer; H. W. Thompson, W. M'Kellar, and W. G. F. Colley, Assist. Engineers, to the *Duncan*; C. J. Martin, supernumerary in the *Asia*, confirmed as Engineer; A. F. M'Intyre, supernumerary in the *Cumberland*, confirmed First-class Assist. Engineer; R. Simpson, Chief Engineer, to the *Prince Consort*; C. Wright, Chief Engineer, to the *Fisgard* from the *Hecate*; W. C. B. P. Jones, Engineer, to the *Prince Consort*; J. Elwess, D. Wishart, R. B. Turner, and H. J. Hall, Assist. Engineers to the *Prince Consort*; C. Dickson, Chief Engineer, to the *Hector*; T. E. Buckle, Engineer, to the *Dauntless*; T. E. Woodfield, Acting Engineer, to the *Hector*; C. H. Thompson, L. M. Green, J. Turner, and J. J. Taylor, First-class Assist. Engineers, to the *Hector*; J. Wootton, Acting First-class Assist. Engineer in the *Immortalité*, promoted; and A. Leitch, Second-class Assist. Engineer in the *Duncan*, promoted; H. Birch, Engineer, to the *Euryalus*, as supernumerary; W. Collier, Engineer, to the *Blenheim*; W. R. Leeson, Engineer, to the *Shamrock*; A. Pritchard, J. Butchart, and J. Galbraith, First-class Assist. Engineers, to the *Euryalus*, as supernumeraries; G. Whitting, First-class Assist. Engineer, to the *Colossus*; F. N. Thornton, First-class Assist. Engineer to the *Edinburgh*; R. Spiers, First-class Assist. Engineer, to the *Asia* for the Tender; J. Torkington, H. Coller, H. Brown, G. Alexander, G. Hancock (b.), W. M'Neil, D. Crichton (a.), and J. O. Wilson, Second-class Assist. Engineers, to the *Euryalus*, as supernumeraries; R. Green, Second-class Assist. Engineer, to the *Russell*; W. Johnston, Second-class Assist. Engineer, to the *Cornwallis*; R. Winfield, Second-class Assist. Engineer, to the *Dauntless*; G. Park, Second-class Assist. Engineer, to the *Majestic*; E. Chambers, Second-class Assist. Engineer, to the *Hogue*; W. Curtin and C. Beal, Chief Engineers, to the *Fisgard*, for the *Niger* and *Spiteful*, respectively; W. Roberts, in the *Indus*, for the *Forth*; J. Boxell, in the *Liffey*; H. W. White, in the *Blenheim*; E. D. Dooley, in the *Euryalus*; J. C. Weeks, in the *Eclipse*; M. Beaks, in the *Racehorse*; J. B. James, in the *Trafalgar*; T. F. Hight, in the *Resistance*; T. Baldwin, in the *Fisgard*; J. Ritchie, in the *Jason*; R. W. Topp, in the *Magicienne*; and J. Lester, in the *Wildfire*, promoted to the rank of Engineer; W. J. Brown, Engineer, qualified for special charge to the *Victoria* and *Albert*, for the *Elfin*.

MILITARY ENGINEERING.

TRIAL OF ARMOUR-PLATES IN DENMARK.—These trials, which recently took place, lasted over several days. Five plates were experimented upon—namely, one from Gaudet and Co., Lyons; one from the Lancefield Company, Glasgow; one from the Thames Ironworks, London; one from Messrs. Rigby's Works, Glasgow; and one from the Atlas Works of Brown and Co., Sheffield. All the plates were of about the same size—15ft. by 3½ft.; each was 4½in. thick, and backed, to resemble the *Warrior* target, which is everywhere taken as the standard of resistance, upon 18in. of teak beams. The guns used were the usual 95 cwt. 68-pounder naval ordnance, loaded with the full service charge of 16lb. After three shots at each plate those of Gaudet and Co., the Lancefield Works, and Thames Ironworks were so injured as to be declared by the Commission to be unfit for further competition. Messrs. Rigby's plate received four shots as close together as they could be aimed, and Messrs. Brown and Co.'s five shots, similarly directed, in a small space, without either showing signs of crack and very little of yielding. The firing was resumed on the 4th ult., when another 4½in. plate of Messrs. Cammell and Co., of Sheffield, was added to the list of competitors, and it was then determined by the Commission to continue the firing as nearly as possible upon the same spot on each plate till it was fairly destroyed. Messrs. Cammell's plate was the first of the three which yielded. Eight shots destroyed it, but both the seventh and eighth carried away large pieces of the iron which had previously cracked. Messrs. Rigby's plate took seven shots in addition to what it had received on the first day before it was broken through, and the eighth shot carried a large piece of the plate through the backing. The firing at this plate, however, had, as it happened, been more concentrated than that against Cammell's. Messrs. Brown and Co.'s plate received nine shots, in a space of 60in. by 30in. The ninth shot cracked the plate severely, but no part of it was broken, nor, comparatively speaking, was the backing injured. The Danish Commission, therefore, declared the order of merit to be—Messrs. John Brown and Co., Sheffield, first; Messrs. Rigby and Co., Glasgow, second; and Cammell and Co., Sheffield, third.

EXPERIMENTS AT PORTSMOUTH.—On the 13th ult., at Portsmouth, some firing took place at armour-plates with cast-iron, wrought-iron, case-hardened, and steel shot, from the 95cwt. 68-pounder and Armstrong 100-pounder, muzzle-loading, smooth-bore guns The target-ship *Monarch*, was placed at the practice moorings in Porchester creek in order to test a 5½in. plate sent in by the Mersey Steel Ironworks for the iron frigate *Agincourt*, and advantage was therefore taken of the opportunity to test some steel and wrought-iron shot at the same time. The plate sent in by the Mersey Company had three cast-iron shots fired at it from the 68-pounder with 16lbs of powder, which produced the usual indents of nearly two inches in the centre of the plate struck, and then broke up into a thousand fragments. The plate was found to crack in the immediate vicinity of the blows, owing to its evident hardness, but the general results of these three shots were such as are seen on most ordinary testing trials of wrought-iron armour-plates fired at with cast-iron balls. The fourth and fifth shots at the same plate were fired from the Armstrong smooth bore with a charge of 25lbs. of powder, the shots being composed of Bessemer steel, manufactured by the Bolton Steel Works Company, and weighing respectively 113lb. and 114lb. Both these struck on the lower edge of the plate, one 4in. the other 5in. on, and cutting through the plate's outer surface broke away its back in large irregular pieces, driving the whole of the fragments into the ship. On inspecting the inside of the ship a large gap was found through the planking, timbers, and deck, and the gun deck covered with a mass of wooden splinters. On examining the hold below fragments of the two shots were found to have gone through the ship's lining and lodged in the timbers on the opposite side. The next shot, of the same description as the

last two, was fired from the same gun with a similar charge of powder. This shot struck the plate fairly in the centre, and cut its way through the plate's outer face with a hole of 10in. in diameter, carried away large portions of metal from the plate's back, and drove them into the ship's side, the shot remaining embedded in the mass of broken iron and ship's planking and timbers, with its outer surface nearly 2in. below the plate's outer surface. Inside the ship the timbers and planking were found to be broken and driven inwards at the deepest part 12in. beyond the plane of the ship's side in a space 4ft. long by 2ft. 3in. wide. The ship's side altogether in this space was nearly destroyed. The succeeding shot was directed at the same plate from the same gun, and with a similar charge of powder, but the shot was somewhat differently manufactured. It had been supplied by Messrs. Frith and Co., of Sheffield, and weighed about 1lb. more than the Bolton Company's shot. It was of steel, but not of the Bessemer manufacture. This shot struck the plate fairly, and buried itself below the plate's outer surface in a hole with a diameter of 10in., opening a semi-circular fissure round the hole which extended right through the plate to its upper edge, and evidently tore away large slabs from the back of the plate. On examining the inside of the ship, the shot was found to have struck immediately in front of a massive wooden knee, and this had evidently held up the planking and timbers in their position and prevented the shot entering the interior of the ship. In performing this duty, however, the knee was split up and shattered from top to bottom. The last shot fired was from the 95cwt. smooth bore, the shot being of wrought-iron and case-hardened, and fired with the usual service charge of powder of 16lb. This shot was sent against a 4½in. plate, which it struck on its lower edge. It broke away about 4in., the piece so broken being semi-circular, and measuring along the arc 33in. This extent of mischief done, the shot rebounded from the place into the water.

French Rifled Gun.—The *Moniteur de la Flotte* states that a rifled steel cannon has been cast in one of the imperial foundries, which is superior to anything yet produced by Sir W. Armstrong. It was tried at the Polygon of Gavre, near Lorient, and that the ball passed through a target as strongly plated as any frigate afloat at a distance of 1,000 yards. Its superiority over Sir Wm. Armstrong's gun is said to consist in its comparative lightness, and in the facility with which it can be manœuvred.

Bessemer's Steel Spherical Shot.—In a letter which recently appeared in the *Times*, Mr. Henry Bessemer states, that "It is marvellous how the advantages of using such a material as cast-steel shots for projectiles did not force itself on the attention of every practical artillerist, irrespective of any efforts on my part, for there is scarce a schoolboy to be found who does not know that a snowball flung with great force is perfectly harmless, while a stone or other solid substance of equal weight would inflict a severe injury, simply because the snowball will fall to pieces on striking the object, while the stone would remain entire, and consequently administer the whole force with which it was thrown. Now, the way in which a cast-iron shot is broken and scattered in a shower of small fragments on striking an armour-plate bears a very strong analogy to the snowball in the case supposed. Indeed, it must be obvious to every mechanical mind that when a cast-iron shot is shivered in atoms against an armour-plate the force expended in the disintegration of the solid spherical mass must be considerable; and it must be equally clear that the force so expended is not a new force created for that especial purpose, but it is part of the original force imparted to the shot, and that the force so expended on the shot must consequently be deducted from the available force to be expended on the armour-plate, and hence the great inferiority of cast-iron as compared with steel shots, since the latter are not crushed by the force of the blow. It is not less remarkable that while our firm have manufactured at Sheffield some 150 pieces of Bessemer steel ordnance for foreign service, guns made of this material are still untried by our Government, although it is well known that the strength of this metal is double that of ordinary iron, while such is the facility of production that a solid steel gun block of 20 tons in weight can be produced from fluid cast-iron in the short space of twenty minutes, the homogeneous mass being entire and free from weld or joint. It has been stated that the hull of the *Minotaur* weighs 6,000 tons, and her 4½in. armour 1,850 tons, making a gross weight of 7,850 tons. Now, had the hull of this vessel been built of a material possessing double the strength of ordinary iron her weight might theoretically have been reduced to 3,000 tons, but practically it would be wise to estimate more liberally, so that, while we admit a double strength of material, suppose we only reduce the weight by one-third, this would give 4,000 tons of steel for the hull. Now, with this reduction in the weight of the hull, we may employ 9in. armour-plates in lieu of the 4½in. armour-plates now employed. This would give 3,700 tons of armour and 4,000 tons of hull, equal to a gross weight of 7,700 tons, or 150 tons less than the weight of the vessel as now constructed; and it must be borne in mind that the resistance offered by the armour-plate is equal to the square of its thickness, hence a vessel constructed in the manner proposed would bear a blow of four times the force that the present structure is calculated to withstand. These weights given in round numbers are sufficiently accurate to explain the principle of construction which I propose, and the important advantages which it holds out. It must not be supposed, however, that such a change would entail any of those difficulties which attended the change from wooden ships to iron ones, for what I purpose is merely to employ a very strong and tough material in place of a much weaker one, so as to reduce the weight of the ship in nearly the same ratio. Such artisans as are now employed can work this metal with facility; the same machinery will cut and fashion it, and, indeed, all the present appliances of the iron ship-builder will remain perfectly the same as at present. Already two ships are being built in foreign waters entirely of Bessemer steel, and the plates for a merchant vessel to be built in England have been ordered. It surely therefore would not be premature in our Government to investigate this subject most fully, for if a ship can by the means I have pointed out be enabled to carry 9in. armour-plates, we may rest assured that other nations will not be long without them."

STEAM SHIPPING.

Steamship Building on the Clyde.—Messrs. Scott and Co. have launched a screw of 600 tons, named the *Albion*, and intended for the New Zealand trade. Messrs. W. Simons and Co., of the London Works, Renfrew, have launched a screw named the *Little Ada*, built for an English firm, and intended for the West Indian trade. She was launched with her engines and boilers on board. Messrs. J. and G. Thompson, of Govan, have launched a screw of 1,000 tons burden and 250 horse-power, intended for the Australasian Steam Navigation Company, which now possesses altogether a fleet of 25 steamers. The *Greyhound*, built for coasting purposes in Australia, has been sold to a Glasgow firm on American account; at her final trip she attained a speed of 13¾ knots per hour. The *City of Brisbane*, launched by Messrs. A. and J. Inglis, for the Australasian Steam Navigation Company, has made a trial trip, in which she attained the speed of 12 knots per hour. This result was considered satisfactory, having reference to the small power of the engines in proportion to the size of the ship. The dimensions of the *City of Brisbane* are as follows:—Length of keel and fore-rake, 220ft.; breadth moulded, 27ft.; depth moulded, 13ft. 6in. She is fitted with a pair of oscillating engines, the diameter of the cylinders being 48in., and the length of stroke 5ft. Messrs. Blackwood and Gordon have launched a screw, intended for the China trade. She has been built for Messrs. Trautmann and Co., of Shanghai, and is fitted up for European and Chinese passengers. She has been named the *Yuen Tze Fee*, and her dimensions are:—Length, 190ft.; breadth, 26ft.; depth, 12ft. 6in. She is to be propelled by a pair of direct acting engines of 100-horse power. Messrs. Scott and Co. have launched a paddle named the *Constance Decima*, intended for the Nassau trade. Messrs. W. Denny and Brothers, of Dumbarton, have now on hand a paddle for China, nearly ready, and of 1,340 tons burden, another for China, of 1,900 tons burden, and another for Bombay, of 220 tons burden. They are also building a screw of 870 tons, and three screws for the British India Steam Navigation Company. Two of these vessels are each 1,026 tons burden, and the third will be 1,650 tons burden. Three vessels will be engined by Messrs. Denny and Co. Mr. A. Denny, of Dumbarton has on hand two screws of 1,200 tons each, which are also to be engined by Messrs. Denny and Co. On the 21st ult. there was launched from the building-yard of Messrs. Tod and M'Gregor, Patrick, a fine screw steamer of 876 tons, for Messrs. Burns, of this city. She was named the *Penguin*. The *Penguin's* dimensions are—length of keel and forerake, 220ft.; breadth of beam moulded, 28½ft.; depth moulded, 15ft. She is to be fitted with a pair of direct action engines of 180 horse-power nominal, and will have first-class accommodation for cabin and steerage passengers. The *Penguin* is to be placed on the Glasgow and Liverpool line. She is one of a large fleet now building upon the Clyde for her owners—a fleet comprising not less than 13,000 tons. Of these new vessels Messrs. Tod and M'Gregor are building two—a screw steamer of 3,000 tons burden, for the Atlantic service, and a smaller screw as a tender to the Messrs. Burns's mail service between Scotland and Ireland. The latter service will, during the course of the ensuing season, be entirely re-modelled. It is intended to conduct it by a fleet of paddle-steamers, now being fitted out at Greenock.

Shipbuilding on the Clyde.—The Scottish engineers and shipbuilders were remarkably active last year, the shipbuilding trade having taken a start as decided, compared with the years immediately preceding, as it took in 1854, which was the culminating point of a former period of progress. The vessels built during the past year, and now in the course of being built, represent 266,643 tonnage, or 100,000 tons above 1862, which was much on a par with 1854. Of this amount of tonnage only four per cent. is wood, two per cent. of wood and iron combined, and the balance entirely of iron. The returns are as follows of vessels built or in course of construction:—

	No.	Tonnage.	Horse Power.
Sailing vessels, iron	87	69,657	......
„ wood and iron	4	3,638	......
„ wood	19	10,280	......
Screw vessels, iron	143	130,610	23,815
„ wood and iron	1	1,821	500
Paddle vessels, iron	76	50,637	16,573
	330	266,643	40,888

The shipping interest has not been so prosperous since 1852 and 1853, during the great tide of emigration.

Trial Trip of the Sultan's Yacht "Taliah."—The new yacht, built for the Sultan by Messrs. Samuda, recently made her trial trip. The *Taliah* left Tilbury Fort, and proceeded at a rapid rate to the Nore, where her speed was tried at the measured mile, when the result attained was—Against tide, 16·216 knots; with tide, 19·251 knots, giving an average of 17·75 knots, or 20½ miles an hour. Her burthen is over 1,100 tons. The engines are by Penn, with a double set of boilers; the nominal horse-power is 350. The whole object of the vessel is speed. Space is sacrificed to machinery, and she is built on the finest possible lines. On the return home she ran from the Nore to Blackwall (45 miles) in two hours and five minutes, the tide being part of the way against her.

Shipbuilding in Belfast.—The Belfast Council report that the external trade of Belfast is making such progress that the existing docks are quite insufficient for the commerce of the port, and that the Harbour Commissioners have consequently entered into contracts for the construction of a large floating dock and a large graving dock, the works of which will be immediately commenced. Shipbuilding flourishes there also. Last year 80 vessels, all iron, of an aggregate tonnage of 7,070, were launched, one being a screw steamer of 2,000 tons, and there are now five ships on the stocks.

Trial of the "Far East," Double Screw Clipper.—The trial of the *Far East*, which was recently launched from Messrs. Dudgeon's building-yard at Cubitt Town, took place on the 15th ult. The *Far East* is an iron built ship of upwards of 1,000 tons register, fully rigged as a sailing clipper. The *Far East* is the first of a class of vessels to be employed in the tea trade between Shanghai and London. She is fitted with engines having a combined nominal power of 120 horse. With the assistance of this auxiliary power in taking her up and down the rivers at each end of her voyage, pushing her on her route through the calms, and working her leeward screw in light head winds, it is anticipated that the voyage between Shanghai and London will be accomplished under 75 days, while the consumption of coal will be at the same time so small when under steam that it will not necessitate the ship calling in at any port throughout the whole voyage for a fresh supply. The *Far East* on this occasion was ballasted down to her load draught when with a full cargo of teas on board, 15ft. aft and 13ft. forward, and proceeded down the Thames, with a large party on board, to run the distance to and fro between the Nore and Mouse Lightships. This is reckoned nine miles (statute), and from the Nore to the Mouse the ship went in 54min. 30sec., the return run from the Mouse to the Nore being made in 50min. 25sec., giving a rate of speed to the ship in the first run of 9·9 statute miles, and in the second run of 10·7 miles, the average speed of the two runs being 10·3 per hour. In powers of turning, either with both screws going ahead, or with their motion reversed, the ship exhibited extraordinary powers, excelling even, so far as was possible, the smaller vessels which have been built by the same firm, and fitted on the same principle—*Flora, Kate, Hebe*, and others, whose trials were fully reported in The Artizan.

LAUNCHES.

The Launch of the "Ellen," from the building-yard of Messrs. James Ash and Co., Cubitt Town, took place on the 11th ult. The *Ellen* is a fine paddle steamer, constructed for a high rate of speed and passenger traffic, the computed speed being 19 statute miles an hour. The *Northheath*, the sister ship of the *Ellen*, launched recently by the firm for the same owner, Mr. Thomas Stirling Begbie, was constructed from the same lines. The dimensions of the *Ellen* are, length, between perpendiculars, 240ft.; breadth, 26ft. depth, 13·6ft.; tonnage, 771. The engines, by Mr. John Stewart, Blackwall Ironworks, Poplar, are oscillating, of 250-horse power, and a fine specimen of river engineering workmanship.

The Federal Iron-clad "Dictator" has been launched without accident. She is 314ft. long, 50ft. broad, and 22½ft. deep. Her armour consists of iron 11in. in thickness which is fastened to a backing of 3ft. of oak, and is continued beyond the bows into a projection of 22ft., forming a ram. She will have one revolving turret, 27ft. in diameter composed of iron 18in. thick, in which will be placed two of Ericsson's 13-inch guns carrying projectiles weighing 304lb.

TELEGRAPHIC ENGINEERING.

Telegraphic Progress.—There is now in Liverpool, and in operation at the Electric Telegraph Company's Offices in Castle-street, an instrument which, from its ingenuity of construction and perfection of results, deserves most careful attention. The object is to transmit autograph messages in the exact form in which they are written; and the most complicated figures, designs, sketches, or indeed anything that can be drawn by an ordinary pen, is transmitted as readily as the simplest dot or stroke. It is said that in three years it will be possible to send a telegraphic despatch to Pekin from London and back again in a day. This will be by means of the telegraph now erecting in Eastern Siberia.

Submarine Telegraphs.—A submarine cable has just been manufactured by Messrs. Siemens and Halske, at their cable works, Woolwich, for the French Government. The cable is for the purpose of connecting Carthagena, in Spain, with Oran, in Algeria, and is 115 nautical miles long. The conductor consists of a strand of three annealed copper wires of the best conductivity, each ·038 of an inch in diameter, and weighing together 72lbs. per nautical mile. The resistance of the strand is measured by 18·5 Siemens's mercury units, at a temperature of 20° C. The insulating covering consists of three alternate coatings of Chatterton's compound and the best gutta-percha, bringing the diameter of the core to ·26 of an inch. The weight of the insulating material is 144lbs. per nautical mile. The resistance of the insulating medium varies from 125 to 175 millions of Siemens's units at a temperature of 24° C. without pressure, and from 300 to 400 millions under a pressure equal to 1,400 fathoms of water. The outer covering is composed of two layers of the best hemp strings, dipped in a solution of sulphate of copper, and weighs 200lbs. per knot. It has been laid on under tension, and is incased in a flexible copper sheathing formed of four strips of phosphuretted best copper overlapping each other. The complete cable weighs 7½cwts. per knot, and its breaking weight is 26cwt. Its specific weight is 1·9, and its diameter ·046 of an inch, and its length is 137 knots, as shipped on board the French Government vessel on the 15th of December, and when tested there gave the following results:—Resistance of conductor, 18·2 Siemens's units per knot; of insulating medium, 1,300 units per knot at a temperature of 13° C. This cable is now being laid by the contractors, Messrs. Siemens and Halske.

Bonelli's Typo-Electric Telegraph.—The message is transmitted in the following manner:—When given in at one end of the line it is set up in type, any errors that may occur being immediately discovered and corrected ere transmission. The row of type is then placed in the machine and passed along under a species of comb consisting of five points, each of which is connected by a wire with a corresponding point at the other end of the line. Underneath these last-named five points passes a plate of platinum upon which is placed a paper moistened with nitrate of manganese. Wherever the corresponding point touches the raised letter, it completes the circle, and the electricity, acting upon the solution, decomposes it, liberating the nitric acid and leaving the peroxide of manganese upon the surface of the paper in the form of a brown deposit corresponding with the type at the other end of the lines. The paper is then washed in water to clear away the remains of the solution, and to deepen the colour of the printing, and after being dried is transmitted to its destination. A set of five wires is requisite; but the same wires are used for the up and down traffic; and 400 messages of twenty words each, it is said, have been transmitted by its means in an hour. The proprietors of this telegraph have been enabled to reduce the charges, and transmit telegrams to Liverpool and Manchester, at the rate of 6*d.* per twenty words.

Telegraph to India.—The directors of this company state in their report that the remaining assets have now been disposed of, and that there are no further liabilities. Messrs. Glass, Elliot, and Co., the lessees of the line, have intimated that they will make no deduction from the half-yearly payment of £1,250 for the period ending December 31st last, although the through communication was interrupted for about two months; they reserve to themselves, however, the right to claim the amount (£200) at any future time should they think fit. The directors recommend that a dividend at the rate of 5 per cent. per annum, free of income tax, be paid to the shareholders for the half-year ending 31st of December last,. During the interruption on the Malta cable this company will get the benefit of the receipts on the Alexandria, Cairo, and Suez line; and, in consequence of the recent increase of the local traffic, the directors do not anticipate that there will be any deduction from the dividend of 5 per cent. per annum during the remainder of the lease. Before the term of the lease expires it is confidently expected that there will be a further extension of the telegraph in the direction of Aden, and possibly of India, by which the company's property will be greatly enhanced in value, and the directors will be able either to dispose of the line, or to work it themselves with advantage and profit. The expenditure on capital account to the 31st December was £55,231, including £8,564 transferred from revenue. The revenue account to the 31st of December shows that £8,763 had been received, including £495 brought from the preceding account, and £6,209 expended, leaving a balance of £2,554.

RAILWAYS.

Tramway on Mont Cenis.—The proposal submitted by Mr. Fell, in concert with Messrs. Brassey and Jackson, to the French and Italian Governments, for laying down a tramway on the present Mont Cenis route, covering the same with wooden, iron, and stone galleries, and working it by means of a new and lighter species of locomotive, so that the distance between Susa and St. Michel, which now takes ten, might be safely and regularly traversed in a period of from four to five hours, has been successfully carried out. The first series of these Mont Cenis locomotive experiments for producing a low engine capable of carrying a train of 100 passengers with their luggage over the mountain have had satisfactory results. The trials have been made on an incline of 1 in 13 (the Mount Cenis being 1 in 12), and the experimental engine, a new one on Mr. Fell's peculiar system, has taken up and down the entire load proposed, while the break power for descending is most perfect. A great number of practical and scientific men have been witnessing these locomotive experiments with much interest, and now a second series of experiments is being commenced—viz., on a gradient of 12, and curves of 30 and 50, metres radius combined, for which a piece of line is in process of construction—the *fac simile* of the Mont Cenis. These Mont Cenis locomotive experiments have been carried on at the Cromford and High Peak Railway, Whaleybridge.

Railway Duties.—The following table is extracted from Sir S. Morton Peto's work entitled "Taxation; its Levy and Expenditure."

AMOUNT OF RAILWAY DUTY RECEIVED.

Year.	England. £	Scotland. £	Year.	England. £	Scotland. £
1833	6,131	—	1850	229,750	21,246
1837	16,339	553	1853	274,511	21,901
1840	107,084	5,343	1856	306,345	27,718
1843	149,370	8,996	1861	342,145	30,032
1846	201,286	11,081			

According to the accounts of the Inland Revenue Commissioners, the amount received for passenger duty for 1862 was £313,057, being very nearly 3 per cent. of the whole expenditure of the railway companies.

Iron for Railroads.—According to an official document, just issued, the declared value of iron for railroads exported in eleven months, ended the 30th November, was £3,073,025, against £2,591,792 in the preceding year.

The Great Western Railway Company propose to establish a superannuation and retiring allowance fund by subscription among their officers and servants, and to encourage the same by contributing to it themselves; together with a fund in connexion therewith, providing a guarantee to the company for the good conduct of its officers.

The Traffic Receipts of Railways in the United Kingdom for the year 1863, amounted to £29,953,960. The traffic receipts of 1863 over those of 1862, showed an increase of £1,632,878; the receipts of 1862 over those of 1861, an increase of £626,808; the receipts of 1861 over those of 1860, an increase of £568,391; the receipts of 1860 over those of 1859, an increase of £1,919,766; the receipts of 1859 over those of 1858, an increase of £1,885,153; but the receipts of 1858, as compared with those of 1857, showed a decrease of £408,701, reducing the total increase for the five years of £6,632,996 to £6,224,295.

Railway Fares.—The Caledonian charged last year 1·29d. per mile first-class, 1·19d. per mile second-class, and 0·71d. per mile third-class; the Great-Eastern, 2·50d. per mile first-class, 2·00d. per mile second-class, and 1·00d. per mile third-class (by express trains, 2·87d. per mile first-class, and 2·00d. per mile second-class); Great Northern, 2·13d. per mile first-class, 1·60d. per mile second-class, and 0·99d. per mile third-class (on the affiliated lines the fares vary considerably); Great Western, 2·08d. per mile first-class, 1·55d. per mile second-class, and 0·96d. per mile third-class (by express trains, 2·43d. per mile first-class, and 1·74d. per mile second-class); Lancashire and Yorkshire, 1·60d. per mile first-class; 1·35d. per mile second-class, and 0·70d. per mile third-class; London and North-Western, 1·97d. per mile first-class, 1·45d. per mile second-class, and 0·95d. per mile third-class (by express trains, 2·44d. per mile first-class, and 1·99d. per mile second-class); London and South-Western, 2·72d. per mile first-class, 1·72d. per mile second-class, and 0·98d. per mile third-class (by express trains, 2·70d. per mile first-class, and 1·96d. per mile second-class); the London, Brighton, and South Coast, 2·04d. per mile first-class, 1·47d. per mile second-class, and 0·89d. per mile third-class (by express trains, 2·67d. per mile first-class, and 1·95d. per mile second-class;) the Manchester, Sheffield, and Lincolnshire, 2·53d. per mile first-class, 1·80d. per mile second-class, and 0·98d. per mile third-class; the Midland, 2·37d. per mile first-class, 1·72d. per mile second-class, and 0·97d. per mile third-class; the North-Eastern, 2·27d. per mile first-class, 1·57d. per mile second-class, and 0·89d. per mile third-class; and the South-Eastern, 1·73d. per mile first-class, 1·28d. per mile second-class, and 0·78d. per mile third-class (by express trains, 2·19d. per mile first-class, and 1·65d. per mile second-class.)

Railway Directors.—It appears that the Session will open with 47 railway directors in the House of Lords, and 153 in the House of Commons.

Opening of the Charing-cross Railway.—The Charing-cross branch of the South-Eastern Railway is now open for public traffic. The first train started at ten minutes past seven o'clock on the 11th ult., being well filled, and there were trains as far as Greenwich, at short intervals during the day.

Locomotion by Hydraulic Power.—Mr. W. Symons proposes, for metropolitan underground or other railways, to have fixed steam-engines at convenient distances, whose work would be to pump water into hydraulic accumulators; this water-power under pressure to be conveyed in pipes along the railway: at proper distances, wheels, as in Messrs. Hawthorn's plan, must be placed, but instead of wire ropes each set of wheels must have connected with it a small hydraulic engine; or, where two lines of rail were used, it might be placed between the two. The train, while progressing, would turn on and off the water as required, and thus no useless power would be expended. By the same sort of power he proposes to work through certain wide streets narrow lines of railway contained in and on tubular viaducts, with open latticed sides and bottoms, so as not to obstruct the light and air; these tubular viaducts to be supported on iron arches, one pillar of these arches to be in a line with the curb-stones of the street pavement, and the other against the houses.

RAILWAY ACCIDENTS.

Railway Accident.—On the 7th ult., a fatal accident occurred on the Llanhilleth mineral branch of the West Midland Railway. The gradient on the branch is very heavy, and two engines are always employed in taking the mineral trains from the Monmouthshire line to the West Midland. On the night mentioned a train of 15 loaded coal trucks and the guard's van had gone a considerable distance up the incline or branch, when the couplings of one of the trucks broke, and the waggons behind at once began to move backwards. The coal trucks were completely doubled up.

Collision on the Midland Railway.—A collision took place on the 14th ult. on this line, at Long Eaton, about six miles from Nottingham. About 7 o'clock a train of empty carriages left the Nottingham station for Kegworth, and when passing the old junction at Long Eaton it ran into a goods train. The tender was damaged and one of the waggons was smashed. Fortunately, no one was hurt. The proper signals were up, but, owing to the dense fog, the engine-driver could not see them.

BOILER EXPLOSIONS.

Manchester Association for the Prevention of Steam Boiler Explosions.—At the ordinary monthly meeting, held on the 5th ult., the chief engineer presented his monthly report, of which the following is an abstract:—"During the past month there have been examined 466 engines and 730 boilers. Of the latter, 11 have been examined internally, 75 thoroughly, and 645 externally, in addition to which 11 of these boilers have been tested by hydraulic pressure. The following defects have been found in the boilers examined:—Fracture, 13 (1 dangerous); corrosion, 29 (5 dangerous); safety valves out of order, 2; water gauges ditto, 11 (1 dangerous); pressure gauges ditto, 24; feed apparatus ditto, 2; blow-out apparatus ditto, 51; fusible plugs ditto, 8; furnaces out of shape, 2 (1 dangerous); over-pressure, 6; deficiency of water, 1 (dangerous); blistered plates, 1. Total, 150 (9 dangerous). Boilers without glass water gauges, 7; without pressure gauges, 7; without blow-out apparatus, 31; without back pressure valves, 36. During the past month three explosions have occurred, from which five persons have been killed and four others injured. One of these had been personally examined subsequently to its explosion. No. 44 explosion occurred to a boiler not under the inspection of this Association, and at too great a distance from Manchester to admit of a personal investigation being made, but the following are some of the particulars:—It was a breeches boiler, internally fired, having two furnaces running into one flue. Its length was 15ft. and diameter 6ft., while the ordinary working pressure was 60lb. The boiler rent along the bottom longitudinally from one end to the other, just as if it had been set upon a mid-feather, and the plates thereby corroded away; but it proved on inquiry to have been but six months old, and set upon two side walls, so that a longitudinal rent under these circumstances is peculiar. The cause of the rupture appears to have been as follows:—A heavy cake of deposit, chiefly of salt, and several inches thick, had through neglect been allowed to form inside the boiler along the bottom. This under ordinary circumstances would have not been attended with any dangerous consequences in an internally-fired boiler, since the temperature in the external flues is not usually sufficiently high; but in this case the conditions were peculiar; the boiler, as will be seen by the dimensions given above, was an unusually short one, at the same time that the draught was good, and the furnaces heavily fired. Since, therefore, the course of the flame passed under the bottom of the boiler immediately after leaving the internal flue, it is not difficult to understand how the plates at the bottom of the shell, which were heavily coated internally with sediment, became overheated and then rent. Surface blowing-out would, in all probability, have prevented this explosion. It will be seen that the circumstances of this boiler were such that it was virtually fired internally and externally at the same time, and it therefore affords an apt opportunity for comparing the safety of the two systems of firing, and it will be noted that the explosion was not due to that portion of the boiler which was fired internally, but to that which was fired externally. No. 45 explosion.—This boiler was the result of almost unparalleled recklessness. The boiler was a stationary one of plain cylindrical egg-ended construction and externally fired, being

16ft. long, 3ft. 6in. in diameter, and made of plates three-eighths of an inch in thickness. It was employed for agricultural purposes, and under the charge of a fireman as well as of a superintending foreman or farm bailiff. The engine which it drove had lately undergone repair, and steam was being got up for a fresh start, when the foreman, in spite of remonstrance, persisted in keeping the safety-valve down by sitting on the lever, the carpenter being engaged in the meantime, by the foreman's orders, in cutting a wooden prop to jamb the valve down. Before, however, the prop could be obtained, the boiler exploded, instantly killing the foreman and severely injuring the engineman and the other persons present. The boiler was completely severed into two parts, one portion being blown to a considerable height and thrown to a distance of 150ft., the rent passing through the manhole and the greater part of the second transverse seam of rivets from the front end, which was situated immediately over the fire. The position of the safety-valve on the boiler was such, that the man whilst sitting upon the lever was immediately over the manhole, and both he and the cover, were blown by the explosion in the same direction. With regard to the cause of the explosion, there is no ground for concluding that the steam, although the valve was held down, had had time to attain to the bursting pressure of a boiler of such dimensions as this one was, supposing it to have been in good condition, and there seems therefore reason to think that the boiler had been somewhat weakened by the twelve years' service it had seen, although there can be no question that the immediate occasion of the explosion was excessive pressure caused by recklessness such as these reports have not previously had to record. No. 46 explosion, which resulted in the loss of four lives, occurred to the right hand boiler of a series of three working side by side and connected together. The one which exploded, as well as that next to it, was of Cornish construction, being internally fired, and having a single flue running through it, which diminished in diameter behind the fire bridge. The length of the boiler was 26ft. 3in., the diameter of the shell 8ft. 3in., that of the furnace tube 5ft. for a length of 8ft., and of the flue 2ft. 9in., while the thickness of the plates throughout was scarcely three-eighths of an inch, being especially bare in the furnace. The boiler had been fitted with a feed back pressure valve, a brass blow-out tap, and a glass water gauge, as well as with an ordinary lever safety valve and a steam pressure gauge common to boilers No. 2 and No. 3. The pressure at which the safety valve was stated to have blown off was 40lb. by the gauge, but on calculation it appeared that this should be taken as a minimum, and that with the steam blowing off freely the pressure would, no doubt, rise as high as 45lb. if not 50lb. On examining the boiler, the furnace tube was found to have collapsed immediately over the fire and rent at one of the transverse seams as well as its attachment to the front end plate. The collapse had not extended into the flue behind the fire bridge or affected the conical junction piece between the flue and the furnace tube. As to the cause of the collapse there cannot be a doubt. No flue 5ft. in diameter, made of plates barely three-eighths of an inch in thickness, can be safely subjected to a pressure of 40lb. or 50lb. on the square inch, as this one was; and hence the explosion. The boiler was an old one, and though not materially weakened by corrosion, had evidently been made at a time when the use of high pressure steam was very little understood. The cylindrical portion of the shell was stayed transversely with horizontal bolts both above and below the furnace tube, as well as with others running vertically on each side of it, while the flat ends were stiffened with diagonal stay bolts. No attempt, however, was made to strengthen the large furnace tube, though the weakest part of the whole boiler, while the diagonal rods introduced, are very inferior to the gusset stays now in use, and the horizontal and vertical ones afford but little or no support to the cylindrical portion of the shell. In this instance the boiler was not stirred from its original position, nor the joints of the steam pipes broken, and in order to be in a position to work on with the other boilers, it was only necessary to screw down the junction valve. The principal injury to the surrounding property resulted from the flight of the furnace mountings, which in this case were unnecessarily heavy and included a facing of brick-work, which is always objectionable in such a position. It will thus be seen that in the case of collapse, the weight of the furnace mouthpiece becomes a source of danger, and the fact of damage frequently arising from this cause, and in some cases loss of life, is an argument for the adoption of light wrought-iron furnace mountings, which are far superior as a mechanical arrangement. The insufficiency of this boiler for the pressure at which it was worked, could not have escaped detection either on competent inspection, or the application of the hydraulic test.

ACCIDENTS TO MINES, MACHINERY, &c.

Colliery Accident near Dudley.—On the 11th ult. a pit accident occurred at Bridge End Colliery, Bromley, three miles from Dudley, by which six men were killed. Iron plates are laid on one side of the mouth of every pit, so that there may be a smooth surface on which to wheel away the skips that are sent to bank with coal. An iron rail surround's the pit's mouth, but when men are being let down or drawn up, one side of this guard is lifted off. The men at the above colliery attended as usual, and two bands of them were safely lowered down the shaft. The third band, six in number, then stepped on the skip, and the engineer proceeded to lower them. Just as the men left the surface a man employed on the bank entered the stable to prepare his horse for the day's work. During the night the horse had slipped the halter off his head, and when the man approached him he bolted out at the door. The man was thrown against the manger by the horse turning round, and could not follow him. Fearing that in the darkness the animal might fall down in the pit, he called to some person to stop him. It was, however, too late, for the horse had slipped and fallen into the pit. The skip with the men on it had by this time descended about 60 yards, and the horse came down on the bonnet of the skip with great violence, the rope snapped, and horse and men were precipitated to the bottom.

Colliery Explosion.—Another fatal explosion of fire-damp, in the mining districts of South Wales, which are so frequent, and resulting in the death of 13 or 14 men, recently occurred. The explosion happened in one of the pits belonging to the Llynvi Vale Iron and Coal Company, situate at Maesteg, near Bridgend, Glamorganshire, which is daily raising a large quantity of coal. The colliery was very much injured by the explosion.

DOCKS, HARBOURS, BRIDGES, &c.

Dock Works at Spezzia.—In Spezzia immense works are being carried on. It has been resolved to leave the port of Genoa for the future to the use of merchant vessels, and to place here the great station for the navy of Italy, with a corresponding arsenal, rivalling that of Toulon. The gulf, ten miles long by about six miles wide, has through its entire length good anchorage for ships, and shelter under the adjacent hills. At the upper end of the bay, near the town of Spezzia, the works now in progress will form a harbour wherein the largest vessels may ride safely close to the shore. The sand is being removed so as to deepen the water; and at the same time large moles and docks are being formed, and lined with fine cut stone. For all these constructions and clearances 3,800 labourers are said to be employed, exclusive of 2,000 navvies on the adjacent railway works, which will unite this great port with Leghorn on one side and Genoa on the other. There are six mud-drags employed all day in pulling up sand and twelve small steamers running backwards and forwards to carry it out clear beyond the gulf. It is calculated that the cost of the whole, when completed, will be 48,000,000 francs.

Proposed New Bridge from Wandsworth to Fulham.—It is intended to remove the old bridge, which has been so long an inconvenience to the navigation, and to build a substantial one for carriages and passengers, with approaches and piers commencing at Wandsworth in the York-road, and terminating near the Peterborough Arms in King's-road, Fulham, with an approach road from the latter point, terminating in Moore Park-road, near to where it is crossed by the Britannia-road. The road on the Wandsworth side will commence in York-road and terminate at the junction of the high road from Wandsworth with the high road from there to the new Wandsworth station of the Crystal Palace and West-end Junction Railway. The estimated cost is £40,000.

The South Wales Ports.—The necessity of providing increased dock accommodation at Cardiff and Newport is now engaging much attention. While at the former port the trustees of the Marquis of Bute have projected docks which will involve an outlay of about £3,000,000 sterling, at Newport a scheme for "dockising" the river and another for constructing new docks have been the subject of an animated discussion at the Town Council and Harbour Board. Meanwhile it has been stated, on good authority, that the Great Western Railway Company, by means of an arrangement with the Monmouthshire, is likely to obtain a lease of the present Newport docks. The trade of the port has lately received a considerable impetus, and it is stated that there have been more vessels in the docks than at any former period. Encouraged by this state of things the company are about to increase their hydraulic and steam power (applied to loading and unloading vessels) so as to meet the present requirements; besides which a new company (the Newport Wood and Iron Shipbuilding Company, Limited) have resolved at once to increase their dry dock accommodation so as to take in vessels of about 2,000 tons. This latter is a most important advantage, inasmuch as the want of adequate facilities for repairs has hitherto acted prejudicially to the interests of the port.

The Wear Dock Contracts for the proposed Hendon Dock and entrance have been received, seven tenders, varying in amount from £238,987 to £161,458. The commission advised the rejection of the whole of these tenders, as they were satisfied the work could be done for a much smaller sum. If the commissioners carried out the work themselves in detail, by contract, a large sum might be saved. The engineer said, his original estimate for the work was £85,000, and he was still satisfied that it might be done for that amount in the way indicated in the report. After some discussion the commission resolved to carry out the works themselves, employing small contractors under them. The committee reported, that for the solid inner pier on the north-east side of the sea-outlet, they had received eight tenders, varying in amount from £48,079 to 19,447. These estimates, they also considered, were much higher than the work might be done for, and they recommend that the tenders should be declined. The engineer had prepared another plan and model, according to which it could be accomplished during the ensuing season, at a cost of £12,000, so that by this plan a saving of £8,000 would be effected. They also recommended that the commissioneers should do the work themselves. This also was agreed to. The committee reported that they had received 14 tenders for the construction of the new graving dock, varying from £32,234 to £14,277, and they recommended that the tender of Mr. Hurst, amounting to £14,375, be accepted. There had been only two tenders for the caisson, but they recommended that both be declined, as they were considered too high. They would take steps to have the work done in some other way. The lowest price was £3,384, but they considered the work might be done for £2,500. This portion of the report was also adopted, and the committee were authorised to proceed at once with the work.

Extension of Leith Docks.—An important addition is to be made to the harbour and docks of Leith, which has been found necessary in consequence of the rapidly-increasing trade of the port. A new wet dock is to be constructed on the east side of the harbour, of greater depth and much larger dimensions than any of the existing wet docks on the west side—in point of fact, nearly doubling the present wet dock accommodation. From a paper descriptive of the scheme read at the Royal Scottish Society of Arts recently, by Mr. Robertson, the resident engineer, it was stated that about 36 acres of the east sands of Leith are to be enclosed by a bank. The dock, with entrance basin and lock, will occupy about 13 acres, leaving about 23 acres for wharfage and other purposes. The area of the dock itself, exclusive of entrance basin and lock, will be $10\frac{3}{4}$ acres, the length being 1,100ft. and the breadth 450ft. The total quayage will be 3,049ft., and the wharves will be 200ft. wide. The entrance lock will be 350ft. long by 60ft. wide, with a depth of water on the sill of 26ft. 5in. at high water of spring tides. The sill depth will be only 2ft. greater than that of the Victoria Dock, opened in 1850; but the effect of that slight addition will be that while there are only 102 tides a-year, which give 23ft. of depth on the sill of the Victoria Dock, there will be 392 tides giving that depth on the sill of the new dock. The depth of water inside the new dock will be 2ft. more than on the entrance sill, to admit of the dock gates being opened some time before and after high water. There will be a front of 1,800ft. towards the town, and a road 60ft. wide will be carried outside the boundary walls of the dock. A branch of the North British Railway is already carried to the site of the new dock, and a branch of the Caledonian, terminating in the west docks, is in course of formation. Contracts have been entered into for the construction of the dock, amounting altogether to about £224,500, and the Loan Commissioners have agreed to make a grant of £223,000 on the usual provision being made for repayment and interest. The work will, it is expected, take about four years.

Improved Hoist-Hook for Collieries.—Mr. Geo. Wild, of the Bardsley Colliery, Ashton-under-Lyne, has invented an improved form of safety-hook, which he anticipates will prove an effectual remedy. A catch falls over the point of the hook, and thus strengthens it, as well as at the same time preventing the possibility of the slipping of a rope.

MINES, METALLURGY, &c.

Gold in New Zealand.—The total value of the gold raised in the province of Otago, in New Zealand, during two years has been £4,024,080. The province of Otago proves to be one vast gold field. Rich diggings are constantly being discovered there.

Australian Gold.—The supply of gold brought down under escort to Melbourne, from the 1st January to the 23rd October, 1863, was nearly on a par with that of the previous year, being 1,160,013oz. The total produce of the Victorian mines, in 1862, was 1,393,874oz.; the average of the three years immediately preceding being 2,014,581oz. The following have been the imports of gold into the United Kingdom from Australia, in the last six years:—

1858	£9,725,108	1861	£6,474,451
1859	9,830,944	1862	6,310.500
1860	6,659,590	1863	5,164,752

Discoveries of Coal in Brazil.—At a recent meeting of the Manchester Geological Society, an announcement was made by Mr. John Plant, of the Salford Museum, respecting the discovery of three extensive coal-fields in Brazil. Mr. Plant said that his brother, Mr. Nathaniel Plant, was the state geologist in Brazil, and he had lately forwarded a description of one of three coal-fields, which were the first that had been discovered in Brazil. Mr. N. Plant, in 1862, fitted out an expedition to the districts of Rio Grande do Sul, and there discovered a large coal field, which had been named the Candiota, extending over about 150 square miles. The second was on the Rio Ratos, extending over about 50 square miles; and the third was in the province of San Catharina, extending over about 80 square miles.

Supply of Fuel in Ireland.—At a scientific meeting of the Royal Dublin Society, recently held, a very valuable paper was read by Mr. Hamilton O'Hara, on "The Supply of Fuel in Ireland," and gave much useful information as to the extent of the coalfields and peat bogs of Ireland, the different varieties of fuel, and how the immense supply of peat, now of little use for manufacturing purposes, may be rendered by improved modes

of preparation nearly as valuable as coal. The area of the bogs of Ireland amounts to 2,830,000 acres, and estimating a cubic yard of dry peat to weigh 550lbs., the quantity of valuable fuel from this source amounts to 6,338,666,666 tons. On pursuing the calculation further, and taking the economic value of turf, compared with that of coal, as 9 to 54, the total amount of peat fuel in Ireland is equivalent in power to about 470,000,000 tons of coal, and estimating coal at 12*s*. per ton, we find the money value of all the peat in Ireland to be £280,000,000 sterling. Mr. O'Hara referred to the particular qualities of coal found in the various coalfields in the provinces, and quoted statistics as to the quantities found in each, the area occupied in Leinster being 230 square miles. There are 73 collieries at present in Ireland, 31 of which are in Leinster, 29 in Munster, 7 in Connaught, and 6 in Ulster. Of these 46 only are at present worked. The quantity of coal taken from them was 120,000 tons a year, but in 1862 it amounted to 127,000 tons. The number of mines now worked was an improvement on that of former years. In 1853 there were only 19 at work, in 1856 there were 22, and now there were 46.

MINERAL WEALTH OF GREECE.—The mines and minerals at present yield only about £4,236 a-year, while the minerals alone should bring the Government a sum of over £40,000 a-year, upon sleeping rents and moderate royalties, which would progressively augment instead of diminishing, and tend greatly to the prosperity of the country, while increasing to a great extent the export and import duties. One marble quarry at Carrara pays far more than all the minerals in Greece, although there can be no doubt that the marbles of Pentelicus and Paros are quite equal to any in Italy. The pure sulphur in Melos, Nalos, and the Gulf of Corinth, ought alone to yield as much as is now received for all the minerals, the amount consumed being greatly increased of late years, in consequence of the vine disease, and the demand for making sulphuric acid. The emery of Naxos would let for more than £4,000 a-year, for it should be remembered that the emery of Turkey, the only other place it comes from, being of a very inferior description, is far from commanding so high a price. The porphyry, serpentine, chalcedony, iron, copper, and lead ores, jasper, manganese, loadstone, sand impregnated with gold dust, malachite, asbestos, rock salt, lapis lazuli, gypsum, meerschaum, antimony ore, lithographic stones, fine colouring earths for paint, and Turkish hones, &c., have never been worked at all. The salt works are a Government monopoly, the actual return being £18,229 per annum. From the general peculation and mismanagement, it is unquestionable that twice as much could be obtained by means of a small outlay. There are 16 in all—3 in the Peloponnesus, 8 in the continent, and 5 in the islands—but they are not all at work. The expense of making the salt is scarcely anything. The almost unlimited demand for salt for the interior of Turkey and the northern part of Africa, would enable Greece to create a large trade in this article.

THE COALFIELDS OF ENGLAND.—The following is from the *Quarterly Journal of Science*:—Nothing is more liable to error than prospective statistics; it is, however, necessary to say a few words in vindication of what may appear the somewhat arbitrary limit of depth which we have adopted in the calculations of our coal resources. The reader will be justified in inquiring why we prefer 4,000ft. to 5,000ft. on the one hand, or 3,000ft. on the other, and he is, therefore, entitled to a reply. Taking the latter figure first, we may state at once that this depth has already been attained, or very nearly so, in more than one colliery, both in our own country and on the Continent, and no colliery manager will maintain that a limit has been here reached. With regard to 5,000ft. as a limit of depth the case is otherwise; for we have reason to conclude that supposing this depth to have been attained, the temperature, not to speak of other obstacles, would be found so high as to forbid the employment of human labour. . . . Even at a depth of 4,000ft., a temperature may be expected more than tropical, though less than it would be at 5,000ft., and sufficient, we think, to place the limit to depth within the last-mentioned figure. The means by which the temperature even at 4,000ft. may be reduced so as to admit of healthful labour is ventilation, and the question remains, to what extent can this be accomplished? A series of interesting experiments, at the Rose Bridge Colliery, give the following general conclusions:—That in a mine of ordinary extent the temperature can be lowered by 20° or 30°, according to the distance from the shaft and the season of the year. The cool air of winter reduces the heat of the mine more than that of summer time, so that even with a depth of 4,000 it may be often impossible to excavate the coal except during the colder months of the year. Probably not more than 10,000,000 of tons of coal were raised at the commencement of this century; yet in 1830 the quantity raised was 30,000,000, and in 1851 not less than 54,000,000. From 1854 downwards we have the returns of the Mining Record Office, which show a general tendency to expansion, though with fluctuations; the maximum having been reached in 1861, when the enormous quantity of 86,000,000 of tons was brought to the surface. Notwithstanding these facts, however, it would be rash to assume that the experience of the past is to be a criterion of the future. We neither wish for nor expect an increase during the remainder of this century at all proportionate to that of the earlier half, and this view is borne out by some of the later returns. Some of our coalfields have passed their meridian, and having expended their strength, are verging on decay. Others have attained their maximum, or nearly so; this, indeed, is the case with the majority. The younger coalfields will have much of their strength absorbed in compensating for the falling off of the older; so that in a few years the whole of our coal-producing district will reach a stage of activity beyond which they cannot advance, but around which they may oscillate. Entertaining these views, we are inclined to place the possible maximum of production at 100,000,000 of tons a year; and yet it has been shown that, even with this enormous "out-put," there is coal enough to last for eight centuries.

APPLIED CHEMISTRY.

DISCOVERIES IN PHOTOGRAPHY.—Dr. Van Monkhoven has just published a method for obtaining positive impressions by means of the oxalate of peroxide of iron. This substance is obtained by taking sulphate of iron in small crystals, and pouring in a little nitric acid. The sulphate is dissolved and red fumes are evolved. A mild heat will hasten the operation. The acid should be added in a sufficient quantity to transform the crystals into a yellow liquid, but without being in excess. The liquid is then diluted with water, filtered, and a hot solution of the hydrate of baryta is added, but not sufficient for saturation. We thus get a precipitate which is a mixture of peroxide of iron and sulphate of baryta. This is well washed by letting it deposit at the bottom of a vessel and stirring it up at intervals, and each time with fresh water. The precipitate is then put into a porcelain evaporating dish and heated, with a gradual addition of bi-oxalate of ammonia, until the precipitate has become white. It is now dissolved: the insoluble part is sulphate of baryta, which may be thrown away; the remaining solution is evaporated, and then left to crystallize; this is the required oxalate of peroxide of iron. All these operations must be performed by night or in the dark. To prepare the paper, dissolve 300 grammes of the oxalate of iron and of ammonia, and keep this solution in a dark place till wanted. The paper must be coated with gelatine on the best side, and the wrong side marked with pencil. Pour the solution into a porcelain basin, lay the paper on the liquid surface, the wrong side upwards, and let it float for four minutes, then hang the leaves up, and let them dry in the dark. Both the solution and the paper may be kept indefinitely, provided they be protected from daylight. In order to receive an impression, the paper is exposed for eight minutes at the utmost, according to the luminous intensity and the nature of the impression. In order to develop the image, which is but weak and negative on leaving the frame, the sheet is stretched on blotting-paper, and brushed lengthwise with a ball of cotton steeped in a solution of one part of nitrate of silver in 20 parts of distilled water. By the action of light the peroxalate of iron has been changed into a proto-oxalate, which has the property of taking possession of the silver contained in the nitrate. Hence the image at once appears of a fine purple colour. The impression is now washed several times, and the operation is successfully ended. Instead of nitrate of silver, chloride of gold may be used to develop the image, which is then violet, and need only be washed once.

ELECTRIC FERTILISER.—Under this title the Abbé Moigno, describes a process by M. Bazin, for converting the nitrogen of the atmosphere into nitrate of ammonia, and using it for fertilising the soil. Water, in a state of extremely minute division, is caused to pass into a reservoir; a blowing machine forces into this artificial fog, as it may be called, a large quantity of air, which thus becomes saturated with moisture; sparks from an electro-magnetic machine are continually passed through this mixture of oxygen, hydrogen, and nitrogen, which cause the formation of nitric acid and ammonia and nitrate of ammonia. The water which is not decomposed dissolves the salt, and the reservoir in a short time contains a solution of nitrate of ammonia, of sufficient strength to be employed in the fertilization of the soil. M. Bazin states that a litre of water thus treated will give one gramme of nitrate of ammonia. The chief expense is the fuel consumed in driving the magneto-electric machine, and the operation resolves itself into a transformation of coal into nitrate of ammonia. M. Bazin then proposes to use a machine, which he terms an "electric fertiliser," which is in the shape of a plough, the share of which, in the form of a knife, cuts the soil to the depth of about fifteen centimetres. The two poles of a small electro-magnetic machine, giving off a number of long sparks, are placed in communication with the soil. The apparatus is carried complete on a carriage, and is sufficiently light to be drawn by one horse. To it is affixed a cask for watering, with a cock for letting off the liquid placed close to the ploughshare, filled with the solution of nitrate of ammonia produced as above, or with any other liquid manure suitable for the soil or the crop intended to be grown. The description of this machine and its action is by no means clear, but such is all the information that is at present given. How far the production of the nitrate of ammonia by this process, and its use by means of the above machine is economical, M. Bazin does not give any data for calculating.

ON THE SEPARATION OF STANNIC AND TUNGSTIC ACIDS, BY C. RAMMELSBERG.—According to H. Rose, these acids may be separated by heating them in a stream of hydrogen. When the reduction is attempted in a porcelain crucible, a loss is always experienced, arising from the oxygen of the stannic acid, which is reduced to metal, and a third of the oxygen of the tungstic acid, which changes to tungstic oxide. By boiling in hydrochloric acid, the tin is dissolved, and can be precipitated by sulphuretted hydrogen, while the tungstic oxide is reconverted into tungstic acid by ignition in the air. After analysing the compound of stannic and tungstic acid with iron and manganous oxide, described in the memoir mentioned below, I was induced to investigate this method, and first of all employed weighed quantities of the two acids. 1st. 1·065 of pure stannic acid and 2·375 of pure tungstic acid lost, after the first half-hour's ignition (at about a temperature at which, under equal conditions, tinstone would be reduced), 0·43. At a stronger heat, 0·115 more; together, 0·445. And by a still longer continuation of the process, 0·085; total, 0·63. 100 parts of the mixture employed contained—

		Oxygen.		
Stannic acid	30·96	6·625		6·625
Tungstic acid	69·04	$14·201\frac{1}{3}$	=	4·764
	100·00	20·916		11·389

If, therefore, the stannic acid was reduced to metal, and the tungstic acid to oxide, the loss should amount to 11·39. Instead of this, however, the loss after the first heating amounted to 12·50 per cent.; after the second, 15·84 per cent.; after the third, 18·31 per cent. Thus, at the commencement, a portion of metallic tungsten was produced, the proportion of which naturally increased afterwards. The residue ought to have given with hydrochloric acid only a colourless solution of chloride of zinc; but, instead of this, it gave first a blue and then a brown solution, while a part remained undissolved, which, by heating in the air, formed tungstic acid. The brown solution was filtered, but, after dilution, it became decolourised, and deposited yellow tungstic acid. It appears, therefore, that it is difficult to conduct the operation so as to ensure the reduction of the tungstic acid only as far as the oxide WO_2, and quite as difficult to separate the same from metallic tin by hydrochloric acid. 2nd. To ascertain whether the strong heat of a gas-lamp would also effect a complete reduction of tungstic acid, 1·222 of stannic acid, and 1·803 of tungstic acid, were strongly ignited in hydrogen gas. The loss of weight after the first ignition was 0·491; after the second, 0·631; and after the third, 0·645. 100 parts of the mixture contained—

		Oxygen.
Stannic acid	40·4	8·645
Tungstic acid	59·6	12·337
	100·0	20·982

The loss of weight in the above experiment, expressed in per centages, were as follows:—After first heating, 16·23; after the second, 20·86; after the third, 21·32. The last number is somewhat higher than the calculation requires, probably in consequence of the volatilisation of some of the tin. In this case the reduction was complete. The grey pulverulent mass contained white, malleable granules of tin, gave a colourless solution with hydrochloric acid, and left a black residue, which, ignited in the air, gave 0·778 of yellow tungstic acid, answering to 58·78 per cent. (Loss 0·82 per cent.) 3rd. 2·212 of stannic acid and 2·116 of tungstic acid lost, after several hours' strong ignition, 0·88 = 20·33 per cent. The mixture contained—

		Oxygen.
Stannic acid............................	51·11	10·937
Tungstic acid	48·89	10·120
	100·00	21·057

In this instance, therefore, the reduction was almost complete. Rose's method may also be employed under the supposition that the tungstic acid is reduced to metal. This point, however, cannot be ascertained by a constant weight of the residue, inasmuch as, in consequence of the volatilisation of the tin, the weight continues to diminish. For the same reason the direct estimation of the tin by this method is impossible. Rose, who has shown that stannic acid, when ignited with sal-ammoniac, is completely volatilised, states also that under the same circumstances tungstic acid remains unchanged, but that, in the presence of alkalies, tungstic oxide, tungstenamid, and nitride of tungsten are formed. I have employed chloride of ammonium as a means of separating quantitatively the two pure acids, and have obtained satisfactory results. As the conversion of stannic acid into volatile chloride of tin requires a long time, the treatment of the mixture with six or eight times its weight of sal-ammoniac must be repeated several times, until no further loss of weight is observed. Great care must be taken that the outside of the porcelain crucible and cover does not become overspread with stannic acid, which is formed afresh from the chloride and surrounding moisture. Hence the smaller crucible should be placed in a larger one similarly covered, and heated to tolerably high temperature. The residue of tungstic acid is soon coloured green, then blackish; when heated in the air it becomes yellow, and has a constant weight. 1st. 0·6977 stannic acid and 0·7335 of tungstic acid gave a final residue of 0·7225, which after ignition in the air, weighed 0·7255. The difference amounts to 0·008; that is, instead of 51·26 per cent., only 50·7 per cent. was obtained. 2nd. 0·554 stannic acid and 1·332 tungstic acid left behind 1·337 of the latter; that is, instead of 70·62 per cent., I recovered 70·89 per cent. I have employed this method for the separation of the two acids in the combination mentioned at the commencement of this paper.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent, Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated December 24th, 1863.

3257 H. Barber—Cutlery handles
3258 A. Noble—Igniting explosive compounds
3259 N. Lloyd & E. Hargraves—Treating printed and dyed fabrics
3260 W. Marsden & F. H. Stubbs—Locomotive engines
3261 S. S. Gray—Collars.
3262 W. E. Gedge—Kneading machine
3263 H. P. Forrest—Drawing off and measuring fluids
3264 J. Maynes—Artificial manure
3265 W. H. Bowditch—Supplying air to lights in mines
3266 J. Duckett—Furnaces for drying and burning bricks and tiles
3267 R. A. Brooman—Permanent way of railways
3268 J. D. Bryant—Projectiles
3269 T. W. Davenport & S. Cole—Manufacture of ornaments
3270 D. S. Price—Projectiles

Dated December 26th, 1863.

3271 J. V. Boesiger—Sewing machines
3272 E. T. Smith—Exhibiting the flow of real water for theatrical purposes
3273 J. Gjers—Kilns for calcining ironstone and limestone

Dated December 28th, 1863.

3274 T. Hall—Improvements applicable to steam boilers for economising fuel
3275 E. Lindner—Breech-loading fire-arms and ordnance
3276 J. E Billups—Permanent way of railways
3277 E. Bramall—Obtaining and applying motive power
3278 W. Wilson—Ornamenting grate fronts
3279 W. Clark—Slide valves
3280 W. Clark—Purses, bags, and other similar articles
3281 T. Tozer—Ships and vessels of war, batteries, and fortifications
3282 J. B. Crooin—Applying power to windlass and other barrels

Dated December 29th, 1863.

3283 T. Bourne—Cotton gins
3284 H. Reda de Saint Martin—Apparatus for aerial locomotion
3285 L. E. Desestre—Improvements in apparatus for watering
3286 H. Bayley—Cotton gins
3287 W. Whitaker & W. Tongue—Softening and separating fibrous materials
3288 J. Price—Obtaining and applying motive power
3289 N. F. Taylor—Increasing the illuminating power or coal gas
3290 H. Caunter—Manufacture of lubricating matter
3291 D. Naylor—Looms
3292 J. Cumming—Giving motion to sewing machines
3293 W. M. Peniston—Constructing and arming ships and floating batteries
3294 J. M. Vanderfeesten—Heating, boiling, evaporating, and distilling

Dated December 30th, 1863.

3295 A. Whitelaw—Treating brine from salted flesh or fish
3296 T. B. Cochrane Earl of Dundonald—Production of hydro-carbon and other oils
3297 J. Patterson—Grinding, crushing, and shelling vegetable produce
3298 W. E. Gedge—Teasling machine
3299 M. C. E. Houdayer & J. J. Cormier—Safeguards for locomotive engines
3300 A. C. J. Leugelee, F. P. Morel, & D. G. M. Coquet—Toys
3301 J. Platt & W. Richardson—Manufacture of rollers
3302 G. Phillips—Aniline colours

Dated December 31st, 1863.

3303 W. F. Brown—Fastening scarfs, ribbons, and neckties
3304 J. Starkey, J. Haworth, & J. K. Phippin—Looms for weaving
3305 R. Bell—Manufacture of ornamental fabrics
3306 J. Clegg—Piled fabrics
3307 J. Dale & H. Caro—Obtaining colouring matters
3308 A. Byrnes & H. Benjamin—Breech-loading fire-arms
3309 J. Radley—Mounting and serving guns used upon vessels and fortifications

Dated January 1st, 1864.

1 J. Holden—Looms for weaving
2 J. Gee—Fluted rollers for preparing and spinning cotton
3 J. W. Nottingham, W. H. P. Gore, & A. H. A. Durant—Carriages
4 E. B. Wilson—Furnaces
5 W. Clark—Chlorine

Dated January 2nd, 1864.

6 W. Muir—Improvements in letter copying presses
7 C. Martin—Preparation of the materials for the manufacture of paper
8 W. Allen & W. Johnson—Grinding cards for carding engines
9 J. & R. Blakey—Looms for weaving
10 J. L. P. Duroy—Soap
11 H. A. Bonneville—Bobbins or shuttles for sewing machines
12 H. A. Bonneville—Improvements in sewing machines
13 W. Ambler—Paper cop tubes
14 W. Clark—Improvements in machines for cutting fodder
15 F Andoe—Securing watches from being stolen from the person
16 W. Balk—Furnaces for smelting ores and melting metals

Dated January 4th, 1864.

17 J. C. Evans—Manufacture of coverings for the head
18 W. Hall—High and low pressure condensing rotary steam engines
19 J. Bullough—Sizing yarns, beams, or warps to be woven
20 J. Askew—Improvements in the construction of window sashes
21 M. Bayliss—Cutting screws and tapping nuts for screws
22 C. Defries—Arrangement of the footlights of theatres
23 A. Lucien Le Harivel—Manufacture of paper, papier mache, and cardboard
24 G. Speight—Collar
25 J. H. Johnson—Sewing machines

Dated January 5th, 1863.

26 R. Tomlinson—Show cases
27 W. B. Barnard—Uniting metallic surfaces for sheathing vessels
28 J B. Fenby—Locks and latches
29 J. H. Whitehead—Felted fabrics
30 J. J Hays—Improvements in the manufacture of peat and charcoal
31 J. Williams & G. Bedson—Improvements in puddling furnaces
32 C. W. Harrison—Improvements in railway signals
33 J. Kidd—Supplying and regulating liquid used in the process of generating gas

Dated January 6th, 1864.

34 G. T. Bousfield—Improvements in knitting machinery
35 W. Malins—Improved system of working atmospheric railways
36 H. Blakey & J. Alderson—Spinning and doubling wool and cotton
37 E Fairburn—Carding wool and other fibrous substances
38 H Nelson & J. Heap—Improvements in self-acting mules
39 R. A. Brooman—Drawing and spinning wool and cotton
40 J. I. & H. G. Tracy—Umbrellas, parasols, and sunshades
41 J. H. Weston & C. Morton—Exhibition of dramatic performances
42 J. Cumming—Sewing machines
43 J. B. Elwell—Construction of ships' masts and spars

Dated January 7th, 1864.

44 A. M. Basset & L. N. D. Lamoureux—Motive power
45 E. G. Camp—Brushes
46 G. Mead—Improvements in tea and coffee urns
47 C. J. Appleby & J. Vavasseur—Coffer dams and quay walls
48 J. Ramsbottom—Hoops, rails, and other articles of cast steel
49 J. Bond—Water gauges for steam boilers and other vessels

Dated January 8th, 1864.

50 R. Adams—Contruction of breech-loading fire-arms
51 W. Pidding—Soles and heels for boots and shoes
52 A. J. S. Graham—Communicating motion by means of fluids
53 I. Lazurus—Fastenings for brooches and other articles
54 J. Rees—Safety lamps
55 J. F. Bland—Supporting targets and protecting the platforms thereof
56 P. M'Laurin—Drying paper, pasteboard, and similar or textile fabrics

Dated January 9th, 1864.

57 P. Walters—Locks, latches, and keys, and connecting knobs to the spindles of locks and latches
58 B. Samuelson—Improvements in smelting iron ores
59 W. Brookes—Steam engines
60 D. Pidgeon & W. Manwaring—Preparing food for animals
61 M. B. Westhead—Improvements in dancing toys
62 J. P. Culver & R. B. Jarvis—Improvements in roller blinds
63 W. C. Beatson—Improvements in glass furnaces
64 J. Coppard—Improved appliances to be adapted to horse shoes

Dated January 11th, 1864.

65 J. Webster—Looms for weaving
66 J. Gibbins—Waterproof and non-combustible tarpaulins
67 W. E. Gedge—Lace-making machine
68 W. H. Barlow—Pontoons
69 J. N. Garrod—Improvements in stock or plasterers' brushes
70 J. S. Jarvis—Scarfs
71 H. A. Bonneville—Engraving
72 H. A. Bonneville—Improvements in telegraphic apparatus
73 J. & J. Clegg & J. Rowley—Pressing, measuring, and rolling textile fabrics
74 S. Woolf—Packing china and earthenware for firing
75 W. E. Newton—Hose coupling
76 J. Coates—Improvements in slide valves for steam engines

Dated January 12th, 1863.

77 H. M. Nicholls—Generating and applying motive power
78 J. Lane—Improvements in motive power engines
79 D. Nickols—Cutting millboard, paper, and other similar materials
80 W. Clark—Preparing fibrous materials from vegetable matters
81 F. H. Twilley & A. Laine—Waterproof adhesive compound
82 W. E. Newton—Improvements in horizontal water wheels
83 J. Browning—Improvements in street and other lamps or lanterns
84 C. Little—Improvements in means or apparatus employed in weaving
85 G. Ash—Manufacture of guns, cannon, and such like ordnance
86 L. E. C. Martin—Supplying water to steam boilers
87 J. Wheatley—Improvements in apparatus for propelling vessels
88 C. Askew—Improvements in sheathing iron ships
89 W. Welch—Propelling, navigating, and governing ships
90 C. Bartholomew—Working coal
91 J. Clay—Cleansing, decorticating, and cutting potatoes and turnips

Dated January 13th, 1864.

92 P. M'Intyre—Shirts
93 S. Robotham—Bird cages
94 G. Wilkins—Construction of breech-loading guns and rifles
95 G. W. Hart—Rifle targets and signalling apparatus
96 T English—Construction of motive power engines
97 M. A. Dietz—Lamps
98 J. F. Bland—Improvements in targets and dummy targets
99 W., G., T., & A. Hanlon—Improvements in gymnastic apparatus
100 W. Denton & J Whitaker—Preventing accidents in mines
101 W. J. Murphy—Improved steam brewing copper

Dated January 14th, 1864.

102 J. Wadsworth—Movable or adjustable heels for boots and shoes
103 J. Connell—Method of ornamenting elastic fabrics
104 J. Rennie—Manufacture of chandeliers and lamps
105 T. W. Plum—Forging, rolling, and shaping iron and other metals
106 N. Thompson—Stopping bottles, jars, and other bottles
107 G. Burt—Improvements in the manufacture of lamps
108 J. Thompson—Manufacture of barrels for fire-arms and ordnance

Dated January 15th, 1864.

109 J. E. Baker—Furnaces for distilling coal and peat
110 M. Wolfsky—Fasteners for bags and other similar articles
111 M. Tongue—Combing, slivering, and preparing fibrous materials
112 A F. Henery—Galvanic belt
113 W. E. Newton—Construction of self-acting hand stamps
114 J. Howard, E. T. Bousfield, & J. Pinney—Improvements in machinery for tilling land by steam power
115 L. Bovy—Improved machinery for driving piles
116 C. Reynolds & J. Barrington—Construction and lubrication of upright shafting and the steps or lower bearings thereof
117 J. Ellis & J. Sladdin—Apparatus for the manufacture of healds
118 P. Cato—Construction of combined iron and timber ships

Dated January 16th, 1864.

119 J. Gill—Destroying momentum and restoring it in the opposite direction
120 D. A. Burr—Lightening arresters for protecting telegraph apparatus
121 W. C. Rogers—Gas lamps
122 W. Balmforth & F. Robson—Improvements in hoisting apparatus
123 A. Shanks—Improved rivetting machine
124 E. Whele—Machine for cutting chaff, roots, or vegetables
125 J. J. Mountain—Improved method of obtaining motive power
126 W. Wood—Covering land, bog, or peat with earth or soil
127 E Lord—Opening and carding cotton and other fibrous substances
128 E. B. Wilson—Fire places

Dated January 18th, 1864.

129 R. Newton—Improvements in the manufacture of spindle bands
130 H. A Bonneville—Adjusting daggers to revolvers and other pistols
131 C. Vogt—Improvements in the manufacture of pigments
132 H. Attwood—Packing for steam engines, pumps, and other machinery
133 C. A. Beckman—Bearings for the axles of railway carriages
134 W. H. Marks—Improvements in musical instruments
135 E. Mainstone—Securing trouser straps to boots, overboots, and shoes
136 R. W. Sievier—Improvements in cocks
137 P. St. George Græme & H. Forbes—Propelling ships or vessels
138 S Wynn—Improvements in hanging window sashes

Dated January 19th, 1864.

139 J. Thompson—Manufacture of fire-arms and ordnance
140 G. Jenner—Sun blinds for railway and other carriages
141 D. A. Burr—Cannon
142 E. J. Vinot—Pneumatic pump to watering apparatus
143 B. P. Gillet de Thorey—Improved case for containing money
144 R. A. Brooman—Machines for sawing and cutting sugar
145 L. J. Cohen—Improved apparatus for cultivating
146 J. H. Johnson—Attachment for lamps or gas burners
147 C. Billson—Manufacture of knitted vests or under shirts

Dated January 20th, 1864.

148 J. D Jobin—Cutting and working stone, marble, and other hard substances
149 J. Hamilton—Improvements in machinery for cutting wood
150 G. T. de Kercado—Using the motive power of steam, compressed air, water, and gases
151 J. Hamer—Machinery for separating the down from feathers
152 T. Lightfoot, G. P. Barnes, & J. Lightfoot—Fixing colours on woven fabrics
153 N. M'Haffie—Manufacture of articles from cast iron
154 J. Davies—Sack holders
155 J. Bowns—Tool for enlarging holes in sheet and other metal

Dated January 21st, 1864.

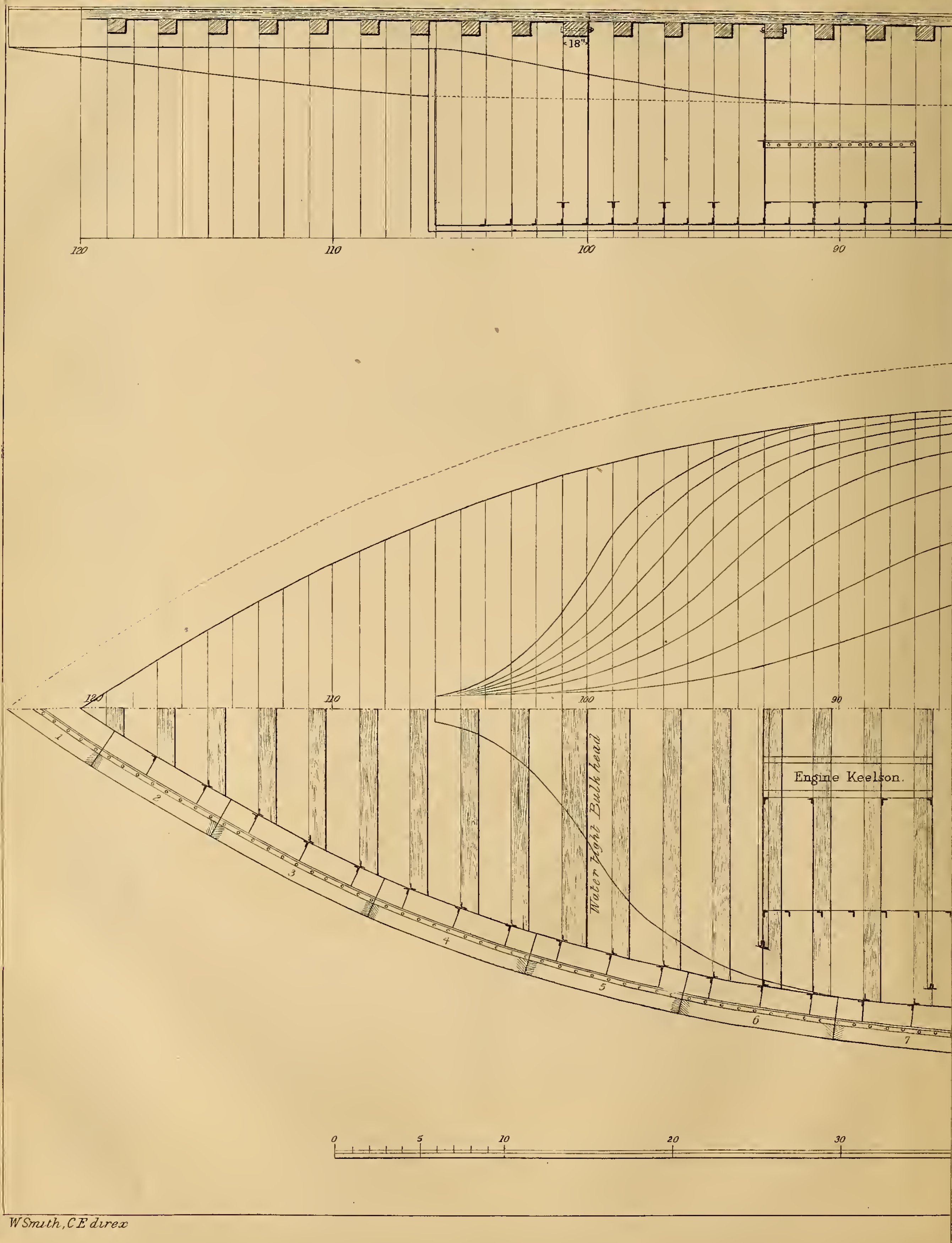
156 J. Wilson—Hydraulic valves for working gas purifiers
157 J. G. Hinde—Brushes
158 G. E. Dooisthorpe—Getting coal, stone, and other minerals
159 H. Brockburst & J. Sullivan—Pressure and vacuum gauges
160 N J le Crun—Arresting the fall of cages or platforms used in mine shafts
161 T. Bayley—Tanning machines
162 M. Henry—Organs and other musical instruments
163 E. T. Jarrold & G. J. Yates—Deodorising paraffin and other oils
164 J. T. Hall—Improved combined lantern and lamp
165 J. Burch and S. Fearnley—Mechanism of looms for weaving terry and cut pile fabrics
166 C. Heptonstall & W. Lunn—Manufacture of stays
167 R. Irvine, T. Richardson, & J. J. Lundy—Manufacture of oils
168 J. H. Johnson—Sewing machines
169 F. J. Ritchie—Application of magneto electricity to the propelling and controlling of sympathetic clocks

Dated January 22nd, 1864.

170 G. Lander—Treatment of tar
171 H. C. Bagot—Vessels
172 F. W. Burton—Securing furniture to floors
173 C. T. Woodman—Closing bottles
174 J. Sewell—Raising or lowering blinds
175 J. Mitton—Cleaning, sifting, and dressing grain
176 W. Clark—Sewing machines
177 J. W. Walton, J. W. Walton, jun., and H. C. Walton—Protecting vessels and fortifications
178 R. E. Eades—Scarf and necktie rings
179 W. M'Adam—Stoppers and bungs
180 G. Smith—Wheels for locomotive engines
181 J. H. Johnson—Propelling and steering ships

Dated January 23rd, 1864.

182 T. C. Clarkson—Ordnance
183 J. Edwards—Curtain hooks
184 J. Brierley—Belt clasps
185 B. Greenwood—Fancy boxes
186 J. Shaw—Harrows
187 J. Shaw—Lawn mowing machines
188 C. G. de Vonssay—Spinning fabrics
189 T. Markland, T. Williams, and J. B. Sheridan—Paddle wheels
190 D. Y. Stewart—Moulds and cores for casting
191 J. M'Elroy—Construction of stands for casks and barrels
192 F. North—Treating and preparing peat and turf
193 E. Myers and H. D. Gloag—Propelling and steering ships
194 T. Bright—Drying malt, corn, hops, and other vegetable substances
195 R. A. and E. Wright—Furnaces
196 J. Platt and W. Richardson—Preparation of clay
197 T. Stevens—Ornamenting paper, pasteboard, and other surfaces
198 W. E Newton—Steam pumps
199 J. E Dix—Furnaces for steam boilers and other useful purposes
200 E. Lucius—Manufacture and production of colours
201 W. Chapman—Traction engines and vehicles for common roads



W Smith, C E direx

THE ARTIZAN.

No. 15.—Vol. 2.—Third Series.

MARCH 1st, 1864.

UNITED STATES' IRON-CLAD STEAM FLOATING BATTERIES OR MONITORS.

(*Illustrated by Plate* 258.)

We referred to and gave a sketch in The Artizan of February last year of the *Monitor* of Ericcson, and from the great importance which is now attached to the subject of "Iron Clads" in all their varieties and rapidly increasing numbers, including cupolas, turret vessels, &c., we have prepared the accompanying plate, showing at Fig. 1 a longitudinal section, Fig. 2 a half plan of the lines, and Fig. 3 a plan of the deck beams, &c., of one of the American *Monitors* as constructed from the plans and specifications prepared by the Navy Department of the United States Government. The general dimensions of the vessel are as follows :—

Extreme length over armour, 200ft.; ditto of boat proper on water line, 190ft.; length outside of stem and stern posts, 159ft.; extreme beam over armour, 46ft.; breadth of beam of boat proper (moulded), 37ft. 8in.; Depth of hold amidships, from top of beam to skin, 11ft. 10in.; Crown of deck amidships, 5in.; shear of deck, measured on gunwale, 1ft.; distance from stem to extreme end of boat proper, 10ft. 9in.; distance from stem to extreme end of armour, forward, 16ft.; distance from stern post to extreme end of boat, aft, 20ft. 3in.; distance from stern post to extreme end of armour, aft, 25ft.

The side armour is composed of five courses of plates, measuring 5in. in thickness. The three outer plates are 60in. deep, extending from the top of the deck to the top of the shelf which passes round the vessel. The fourth plate from the outside is only 36in. deep; and the fifth, or inner plate, is 30in. deep. No plate is less than 60in. long. Each of the four inner plates are fastened to the bulwarks, with two independent blunt bolts of 1¼in. diameter, countersunk and flush. The outer plates are fastened each by 18 countersunk blunt bolts, 1¼in. diameter, passing through the entire depth of the armour, and driven through the thickness of the bulwark within 4in. The up and down edges of the outer armour plates are planned and accurately fitted.

The bulwarks or armour timbers are composed of a series of vertical blocks of oak 17in. by 12in., held in place at the bottom by a 3½in. angle iron, rivetted to the shelf, as shown in the accompanying woodcut, fig. 1.

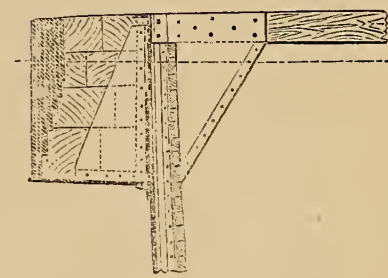
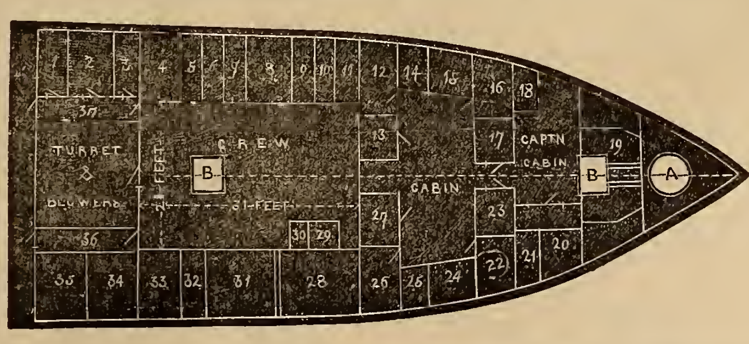


Fig. 1.

At the top the blocks are fastened by bolts, 1in. diameter, passing through the 4in. angle iron which binds the top of the vessel. In addition to this fastening, these vertical blocks are secured by 4 blunt bolts, 1in. diameter, driven horizontally through each of the side brackets which support the shelf. Longitudinal timbers, running from end to end of the vessel, are firmly blunt-bolted to the vertical blocks. These longitudinal timbers vary in thickness, according to the varying thickness of bulwark called for by the general curvature of the vessel. The thickness of the bulwark tapering down from 3ft. 8in. amidships to 2ft. 5in. at the stem and stern. The three lower longitudinal timbers are composed of pine, and the two upper of oak. The plank shear which forms part of the bulwark, is made of oak 18in. wide, measured from the side of the vessel; it is 7in. thick, and secured by blunt bolts to the deck beams, and to the vertical blocks composing the bulwark.

The entire vessel forward of the turret bulkheads, is devoted to the accommodation of officers, crew, stores, and ammunition, as shown in the woodcut given below, in which A is the anchor well, B B the hatches; and the several figures in the different compartments indicate the berths, store-rooms, magazine, &c. We may afterwards have occasion to refer to the turret and turret gear, and some of the mechanical details of and appliances fitted on board these vessels.



NAVAL ORDNANCE.

At the meeting of the United Service Institution on the 1st ult., Capt. Fishbourne, R.N., delivered the continuation of his lecture upon the important subject of Naval Ordnance. He commenced by stating that both the multiform system of grooving—as developed in the original Armstrong gun—and the shunt system, adopted in later guns of the Elswick class, have proved failures: breech-loading had failed, and the coil system proved to be as unsafe in practice as the mode of its application is wrong in principle. Capt. Fishbourne then proceeded to state that the real problem to be solved is, how with the limited strength and the limited endurance of metal, together with the necessity for limiting the weight of guns and of projectiles, to obtain the greater effectiveness. Or, viewing the question economically, how with a given sum of money to obtain a gun that under the varying circumstances of warfare will effect the greatest damage. But artillerists are bound by certain conditions. The distances to be provided for are uncertain in amount, although generally within 2,000 yards. Secondly, with a given weight and strength of gun and weight of projectile, the highest relative velocity and the quickest exit of shot from the gun must be provided for. Thirdly, the gun should possess the capability of being used with spherical as well as elongated shot without injury to the grooving, and be also able to fire molten iron shells, grape, canister, &c. One of the greatest necessities to these conditions is that the size and form of the projectile shall occasion the least tension to the gun. Time and tension should have

U.S. IRON-PLATED STEAM BATTERIES.

FIG. 1. LONGITUDINAL SECTION.

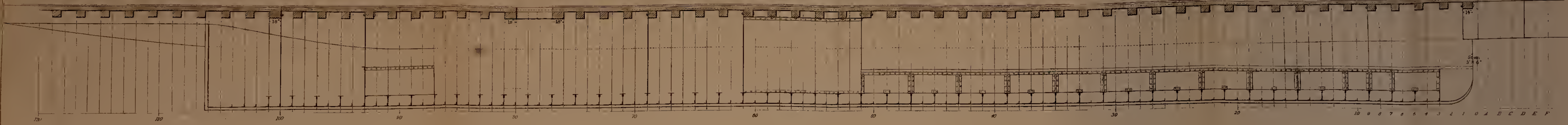


FIG. 2. PLAN OF THE LINES

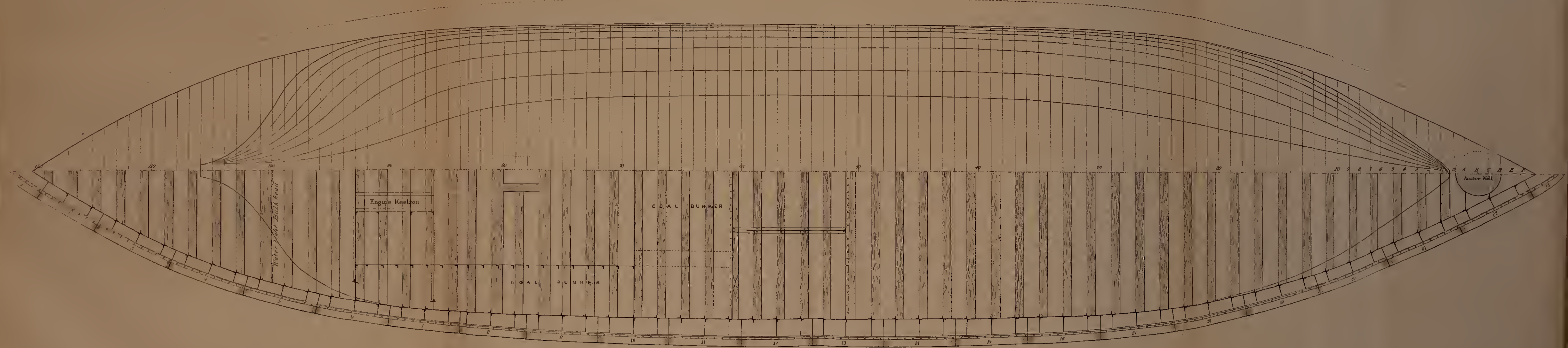


FIG. 3. PLAN OF DECK BEAMS. &c

SCALE OF FEET

W. Smith, C.E. direx

the first consideration, but they have been entirely overlooked by those who have latterly had tbe management of our artillery. In practice the nearest approach to a due adjustment of pressure is to be found in the smooth bore-gun, in which there is a large amount of windage, but which loss can be made up by an increased charge of powder without unduly straining the gun. A rifle projectile causes greater strain upon the gun in consequence of its detention hy the rifling, and also in consequence of its greater inertia. With reference to tension and the absorption of power by reason of the friction which the shot sustains from the numerous grooves of a rifled gun, various experiments have been made. Mr. Bashley Britten's gun, with an expanding rifle projectile and a charge of only one-tenth the weight of the shot used, attained an initial velocity of 1,209ft. per second; while Sir William Armstrong's projectile, with a charge of one-eighth its weight, attained a no higher velocity than 1,140 to 1,200ft. per second. The strain upon Mr. Britten's gun was also less by one-fourth than that upon the latter. One of the Parrott guns, with the same proportion of charge as the Britten guns, and loaded at the muzzle, attained 1,254ft. per second; and other American guns have given 1,244ft. with powder one-ninth the weight of the shot. Then, again, while costly coils are used by Sir William to obtain even the velocity named, Mr. Britten, Mr. Lancaster, Captain Scott, and others used only common cast iron guns in their trials, and the tension that such guns can safely bear is not more than 12 tons per square inch. Another evil of the multigrooving is that the projectile, being larger than the hore, greater heat is engendered by the combustion of the powder, and this heat being communicated to the inner tube, the lead coating of the shot is melted, the hore thus fouled, and the accuracy of firing interfered with. There is also a violent strain arising from the squeeze at the muzzle, both in the multigroove and shunt guns, which tends to pull the chase from tbe breech, and has the peculiar disadvantage of checking the motion of the shot just at the place where acceleration is most required. The inconvenience is especially felt in shell firing, as sometimes the shells burst under the pressure. Lastly, the smooth-bore gun is the safest, and can be fired the greatest number of times without sustaining injury. Having further enforced these points by statistics and a reference to diagrams, Captain Fishbourne pointed out how the shunt guns from Elswick had failed, equally with rifled guns, and in proof of his statements with reference to tbe latter he read extracts from letters written by officers lately engaged in active service in Japan. Calmly reviewing the whole of the facts, the lecturer said that of all the projectiles and systems of rifling that had come under his notice the multigroove was the most erroneous in principle, while the shunt—though decidedly better—was far below many other systems; and, as to the remedy for this state of affairs, it was clear that nothing will compensate for loss of velocity in striking objects clothed with iron, and that up to a considerable range, with medium shot, and at a still greater range with large shot—the strength of the gun being the limiting condition—the sphere gives the highest velocity in striking. Up to a certain short distance a round shell will be more effective than a solid sphere; over that distance and up to another, the solid sphere will be more effective. Next will be a medium elongated shot, and then the elongated shot according to length. The lighter the shot the higher will be the initial velocity; but the *vis inertiæ* being in proportion to the weight, the motion of the light shot will be affected hy this cause, and also by the greater resistance it is subjected to, and therefore it will be more retarded tban heavy shot. There will be little or no penetration by a projectile moving at a certain low velocity. The higher the velocity, the smaller, within practical limits, the projectile that will penetrate. The heavier the shot the lower may be the velocity that will penetrate a given thickness of plate. For a given weight of shot to pass through a given thickness of plate there must be a given high velocity at first impact in proportion as the plate is thick, so that a sufficient velocity may remain to penetrate the last portion of the plate. This shows that no estimation as to penetration at 2,000 yards by a slow moving body can be formed from the penetration effected at 200 yards by a fast travelling body. Passing on to consider the form of shot, the lecturer showed how high velocity was the great necessity to ensure penetration rather than mere form, because it prevented the plate fired at having time to give forth any elasticity.

The best form of cartridge having been next explained, the lecturer proceeded to state that gun cotton seemed to offer great facilities for evolving the gas at the most correct time, and in the quantity required; and that it possessed amongst other advantages freedom from smoke, less beating of the gun, non-fouling of the bore, greater certainty in action, and greater safety.

Having thus pointed out the necessary requisites in an efficient gun, and the absence of those requisites in Sir William Armstrong's guns—how the latter were deficient in velocity and liahle to injury from few discharges; how, also, the shot was injured and the guns unable to stand heavy charges; and how the grip at the muzzle caused injury—Capt. Fishbourne went on to say that the kiud of groove for a naval gun is such a one as is not injured by firing round shot. Iron bearings alone will admit the highest velocities, and it is simply folly to be content with anything short of that; for the higher the velocity the smaller may be the projectile, and therefore the smaller and lighter may be the gun:—that the only two projectiles offering these advantages are Whitworth's and Capt. Scott's; but the inability to fire spherical shot and molten iron is fatal to the former, and the angles are an element of weakness in the gun. This leaves no choice but that of Capt. Scott's, which has this further to recommend it—that it strains the gun less, and is like the French groove, from which the highest comparative results have been obtained. Upon the subject of windage the lecturer said the quantity given to the 300 and 600-pounder Armstrong guns was preposterously small, and unless the 600-pounder was mopped out after nearly every shot, the gun could not be reloaded. In fact, the system of giving rotation by studs does not allow of sufficient windage to produce a maximum result with a minimum strain on the gun.

Coming next to the material of which guns should be made, Captain Fishbourne said that as the action of powder partook of the nature of a blow, the quality sougbt for should be hardness. Cast iron, although at first disregarded, has been proved to be harder tban wrought iron in the proportion of 92 to 38. The tension under compressiou, or hardness, of wrought iron is 17 tons per square inch, aud the cracks and flaws found in the multi-groove coil-made guns after proof, and which increase with practice, arise from the fact that the metal has been compressed and has yielded. In a word, that these guns are all in process of disintegration, and the only reason that they do not burst is that the tensile strain is not reached, on account of their yielding, or that the vent-piece gives way, and so relieves tbe strain; and that there is only one escape—viz., the use of very limited charges and a description of missile designed on mechanical principles.

Referring to the adaptability of Bessemer steel for ordnance, Capt. Fishbourne stated that that should have been adopted when cast-iron was found inefficient, and that it is due to Colonel Wilmot—the predecessor in office of Sir Wm. Armstrong—to say that he appreciated the fact, and began to carry out the necessary work as far back as 1859. Had his counsels prevailed 2½ millions of money would have been saved, and we should have had a gun that might be trusted. The hardness of Bessemer steel is 103,255lb., and the tensile strength 111,460lb., and with this metal Mr. Bessemer offered in 1859 to make guns that would bear a strain of 45 tons to the square inch—that is nearly three times as strong and enduring as tbe Elswick guns. The cost would be about one-fifth that of the Armstrong guns, which taken in connection with the triple durability, would render them fifteen times as valuable.

Captain Fishhourne concluded by remarking that the Admiralty had taken one good step—that of ordering smooth-bore guns to be made, and the next step taken should be tbe adoption of steel instead of wrought iron.

DOUBLE CYLINDER EXPANSION STEAM ENGINES.

In The Artizan of November last we referred to the completion of the *Chile*, one of three large steamships ordered by the Pacific Steam Navigation Company from Messrs. Randolph, Elder, and Co., and fitted by that firm with their system of patent double cylinder expansion engines, to which reference has so frequently been made by us in previous volumes of this journal. We learn from a supplement to the journal *Valparaiso La Patrie*, that the *Chile*, commanded by Capt. C. H. Sivell, arrived at Valparaiso on her first voyage out from Liverpool on tbe 17th December, 1863. The following is the memorandum inserted in the above journal as to the sea performanee of that vessel:—

	Under Weigh. D. H.		In Port. D. H.
Left Livcrpool, Bell Buoy, 3 p.m. 11th November ...	—	...	—
Arrived at Madcira, 3 p.m. 16th November............	5 0	...	—
Sailed from do., 8 p.m. 16th November	—	...	0 5
Arrived at St. Vincent, 8 a.m. 20th November	3 12	...	—
Sailed from do., 4 p.m. 21st November.................	—	...	1 8
Arrived at Monte Video, 5 p.m. 4th December	12 17	...	—
Stoppages at Sea	—	...	0 8
Sailed from Monte Video, 3 p.m. 6th Decembcr......	—	...	1 22
Stoppages in thc Straits	—	...	0 13
Arrived at Valparaiso, 17th December, 2 p.m.	10 10	...	—
	31 15	...	4 8

	D.	H.	M
Time from Liverpool to Valparaiso....................................	35	23	0
Stoppages..	4	8	0
Time under Weigh..	31	15	0

Highest speed attained, 14 knots. Average per hour, 12½ knots.

With the exception of a pampero after leaving Monte Video, which lasted twenty-hours, the weather in the Atlantic was fine throughout. In the Straits of Magellan, as far as Sandy Point (the Chilian settlement), it was beautiful, but at that place it entirely changed. On leaving, the *Chile* was struck by a heavy squall, accompanied by thunder, lightning, and hail; and it continued squally most of the time, blowing with great violence during the remainder of the voyage in the Straits. From Cape Pillar to Mocha Islands, the *Chile* encountered a succession of gales, accompanied by heavy seas. During the severe weather the *Chile* behaved beyond the most sanguine expectations formed of her, and proved herself a most admirable sea boat.

Her speed during the worst of the gales never fell under 10½ to 11 knots. The following are the particulars of the ship:—

Length over all	289 feet
Breadth	36 „
Depth	24½ „
Gross tonnage	1,671$\frac{77}{100}$ tons
Horse-power (nominal)	400 horses
Working up to	1,350 „
Displacement on leaving Liverpool	2,000 tons
Consumption of Coal during voyage	1,022 „

Has accommodation for 200 first cabin and 100 second cabin, besides deck passengers.

We may add that the *Quito*, another of the vessels recently constructed and engined for the Pacific Steam Navigation Company, by Messrs. Randolph, Elder, and Co., left the Mersey on the 27th January, on her first outward voyage for her station on the South Pacific, and made a most satisfactory run to St. Vincent's, being the fastest, we believe, for that passage which has yet been recorded, viz., 7½ days from Waterford, which she left on the 28th January—and where she landed her pilot—and 8 days 4 hours from Holyhead. On the run she averaged from 12½ to 13½ knots, on a consumption of about 2cwt. per knot Welsh coal. She arrived at Madeira on the 1st ult., and reached St. Vincent's at six, a.m., on the 5th ult.

The engineer reports that he had to go easy whilst nearing St. Vincent, waiting for daylight of the morning of the 5th ult. No hot bearings were found, and all was satisfactory in the engine-room.

The total coal consumption was 260 tons, including that for raising steam at Liverpool, &c.

The engines, Messrs. Randolph, Elder, and Co.'s patent double cylinder, are of 320 horse-power nominal, and appear to have averaged 1,250 horse-power indicated, and to have developed about a horse-power for every pound of coals. The two large cylinders are each 90in. diameter, and the small cylinders, 45in. diameter; 5ft. stroke; steam jacketted; and fitted with surface condensers. The boilers are two in number, tubular-fired from both ends, they are loaded to a pressure of 35lbs., contain about 4,400ft. of heating surface, and 190ft. of fire-grate surface; the shells are cylindrical, 11ft. diameter, 16ft. long, and ½in. thick, double rivetted. The furnaces are twelve in number, each 2ft. 8in. wide, and there are four superheating up-take chambers.

The dimensions, &c., of the vessel are as follows:—Length of hull, 290ft; length between perpendiculars, 266ft.; breadth of beam, 32½ft.; depth to awning deck, 29ft.; average draught of water during voyage, 13ft.; ditto midship, section area, 360ft.; displacement, 1,800 tons. This vessel has accommodation for 120 first-class passengers.

The *Payta*, the last of the three ships which we have referred to, as being constructed and engined by Messrs. Randolph, Elder, and Co. for the Pacific Steam Navigation Company, is designed, when finished, to be the fastest of the three. She is 1,300 tonnage and 400 horse-power.

We have referred in previous volumes of The Artizan, to the *Peru*, one of the first of the vessels built and engined by Messrs. Randolph, Elder, and Co., for the Pacific Steam Navigation Company. That vessel continues to run regularly from Valparaiso to Panama. Three of such runs, making in all 18,000 miles, have been performed upon 1,720 tons of coals. It will be remembered that the *Peru* is 1,400 tons builder's measurement, and 400 horse-power nominal. It would thus appear that the *Chile* is a more economical ship, though the tonnage is 300 tons in excess of the *Peru*; and that the dimensions of the *Peru* are not so favourable as those of the *Chile*. Both ships are the same length, but the breadth of the *Chile* exceeds that of the *Peru* by 4ft.

ARMOUR PLATED FRIGATES FOR THE I. R. AUSTRIAN NAVY.

In The Artizan of May last we gave a short notice of the trial of the iron-clad frigate *Prinz Eugen*, being one of three iron-clads frigates (the *Kaisir Max, Prinz Eugen*, and *Don Juan d'Austria*) constructed from the designs of Herr Romako, Chief Naval Architect of the I. R. Austrian Navy. There are now in course of construction at private yards near Trieste two other iron-clad frigates, also designed by Herr Romako, and named the *Hapsburg* and the *Archduk Ferdinand Max*, both vessels being of the same dimensions, and the features in their construction also being the same, viz.:—

	ft.	in.
Length between perpendiculars	262	4½
Beam	52	6
Depth of hold	23	6
Draught forward	20	9
Do. aft	25	8
Tonnage	3,065$\frac{85}{90}$ tons	
Displacement	5,200	„
Midship section area	894	sq. ft.
Area at water line	9,900	„

The plating commences at 4ft. below the water line, extends the whole length of the vessel, and is 5½in. thick, tapering fore and aft to 3¾in.; the tapering commencing about 25ft. from the stem and the stern; the wood backing is from 12in. to 14in. thick. The port sills are 7ft. above the water line.

The bow is formed tumbling home; the bowsprit is withdrawable. She has a bow battery or turret on the forecastle, with two heavy guns pivotted, to be used as broadside guns; the forecastle, looking aft, is plated with 1½in. plate, and provided with boats, guns to sweep the deck, and crenelations for riflemen. The plating at stem allows of the vessel being used as a ram. The coal bunkers are carried up to the lower deck, but a passage left between them and the ship's sides. The after deck has a suitable deck house for the accommodation of the captain and officers. The rudder shaft is protected by armour plating 2½ft. below the water line. The vessel is formed very fine aft, being designed for a high speed.

The ventilation of the vessel is provided for by longitudinal passages with vertical openings fore and aft, and having communications with the cabins, &c.

The armament is proposed to consist of 32 pieces, 130-pounders (23lb. charge); but perhaps fewer and heavier guns (muzzle-loading rifled) may be adopted.

The engines are 800 horse-power nominal, horizontal and similar to the Maudslay type, but having three bearings; the cylinders are 82½in. diameter; 4ft. stroke. The tubular boilers, six in number, proportioned for 1,000 horse-power nominal, have 34 furnaces. The screw proposed is a non-lifting Griffiths, 19f. 10in. in diameter; pitch variable from 26 to 30. The pair of engines for one vessel were made at Trieste, at the *Stabilimento Technico*, or Technical Establishment, and those for the other, at Fiume.

We shall hope at some future time to be able to present our readers with the particulars of the performances of these vessels on trial, and when we may enter into further details.

STEAM BOILER ASSURANCE.

The Chief Engineer of the Steam Boiler Assurance Company, Mr. R. B. Longridge, in his report for the past year, states that the number of boilers proposed for insurance was 2,266, the number accepted by the board being 2,121.

Of the boilers proposed for insurance eleven were declined, being unsafe to work at the required pressures, and the insurance of 199 was deferred, on account of defective condition, or deficiency of mountings, or for further examination; but of this number 49 were subsequently insured on completion of the alterations suggested. The others, with the exception of a small number which have been dispensed with, or replaced by other boilers, still continue working, many of them in great risk of explosion.

The total number of inspections made by the officers of the company, in the course of the year was 18,567, of which 782 were internal, and 1,069 thorough examinations.

The more serious defects reported were as follows, viz.:—

Fractures of plates and angle irons	354
Corrosion of ditto	571
Safety valves out of order, or overloaded	381
Pressure gauges out of order	251
Water gauges ditto	326

The chief engineer then proceeds to remark upon the more important facts that have come under his notice during the last twelve months, and proceeds to state that, of the defects just specified, the cases of corrosion are by far the most numerous. Frequent have been the instances where the inspectors have found plates originally $\frac{7}{16}$ of an inch thick reduced to $\frac{1}{16}$ of an inch or even less; and several of the explosions which have occured, have been solely attributable to hidden defects of this character. The remedy against external corrosion, resulting from leakage or dampness of the brickwork, is self-evident, but it is not so generally known, that an effectual remedy against the internal corrosion, to which many boilers are liable, is fonnd in the introduction of common soda; not in large quantities at the times of cleaning, as is sometimes the practice, but daily in small quantities—say from ½lb. to 1lb. per boiler, according to the degrce of acidity of the water.

Soda is one of the best preventatives of the formation of hard deposits, on the surfaces of the plates, a source of much annoyance in many districts.

One of the simplest modes of introducing the soda is the following:—

Attach to the suction pipe of the feed pump a piece of ½in. or ⅝in. gas pipe, with the other end turned downwards, in the form of a syphon, and having a tap in any part of its length, as most convenient for use. Having dissolved the soda in water, place the vessel containing it under this pipe, and on opening the tap when the pump is working, the solution will at once be conveyed to the boilers. Were this suggestion adopted in all cases, where boilers suffer from internal corrosion, much expense in repairs would be saved, and the duration of the boilers would be extended several years.

In the reports of the inspectors, the overloading and unsatisfactory condition of the safety valves is a frequent source of complaint. As has been above stated, not less than 381 safety valves were found out of order at the times of inspection, some loaded with extra weights, such as bricks, stones, old wheels, broken pipes, pieces of broken metal, &c.; others were inoperative from neglect of cleaning; while others were wedged or bolted down, and thus rendered inoperative, intentionally.

The following is cited in the report as an almost incredible example of recklessness. One of the inspectors, who was sent to examine a boiler proposed for insurance, found it working without any safety valve whatever, and on representing the dauger incurred, he was informed by the owner that it was his intention to attach a valve, but being undecided as to which kind was the best, he had in the meantime allowed the boiler to work without any, the pressure of steam being regulated by the pressure gauge.

The accidents resulting from deficiency of water have been numerous, not fewer than 71 having occurred in the course of the year to boilers insured, although happily none of these have been attended with loss of life.

The majority of accidents of this kind are solely attributable to the inattention of the fireman, and show that, however well a boiler may be provided with gauges or feed apparatus, something more is required to insure safety.

Mr. Longridge is of opinion that a combination of float and safety valve which is recommended by some engineers, is so far useful, that in case of deficiency of water, the valve allows the escape of steam, and thus gives warning of danger; but many instances occurred where, under such circumstances, the flues of boilers, provided with mountings of this kind, have been seriously damaged, although no actual explosion took place. Others advocate the use of alarm whistles, but most of these are very liable to derangement. As to fusible plugs, Mr. Longridge states that with the exception of the fusible caps recommended by the Steam Boiler Assurance Company, he has found none worthy of confidence, and adds, in confirmation of this favourable opinion, that during the last twelve months, 42 cases of deficiency of water have occurred to boilers provided with these mountings, where no damage was sustained, the steam escaping on the melting of the plugs and extinguishing the fires. The only objection to their use, and one that has frequently been raised, viz., that if not kept clean these caps are of no service, is equally applicable to glass tube water gauges, safety valves, and, in short, all boiler mountings.

Mr. Longridge then proceeds to refer to the injury to plates from overheating, notwithstanding a sufficiency of water in the boiler, and states that this is of more frequent occurrence than is generally supposed, though many deny its possibility altogether. Seventeen cases of this kind occurred during the year, and of which the following are instances.

At one mill, where six boilers are employed, five of these suffered successively from this cause, at intervals of a few weeks. Four of these were of the ordinary construction, with two internal furnace flues; the fifth had also two internal furnaces, but these were connected with a combustion chamber, from which smaller flues or tubes conveyed the products of combustion to the end of the boiler, whence they took their course to the chimney in the usual manner. There was nothing peculiar in the construction or dimensions of these boilers, or in the mode of firing. Each was provided with a glass tube water guage, Hopkinson's patent safety valve, and other mountings usually considered necessary. More than ordinary attention was paid to their condition, and none of them were ever known to have been deficient of water. Nevertheless, at short intervals, and without any apparent cause, the flues of these five boilers partially collapsed, where exposed to the direct action of the fire, causing considerable alarm, and necessitating the replacement of several of the plates. A careful examination showed that this, as in many similar cases which had been noticed, was solely attributable to the peculiar nature of the deposit, and the imperfect circulation of the water. This deposit, after floating on the surface of the water, is ultimately precipitated in the form of a fine powder upon the plates, which, owing to the non-conducting property of the deposit, gradually become overheated, and then yield to the ordinary working pressure.

Similar results were observed in two plain cylindrical boilers which had only been at work a few months; and in another instance, where the same kind of deposit was present, one of the plates over the fire bulged outwards, forming a circular hole about 4in. diameter, through which all the water and steam made their escape.

The best remedy against these evils, if water cannot be obtained from another source, is the daily introduction of soda in the manner already described, together with frequent blowing off from the surface. This has been found effectual when all other means have failed. An analysis of some of these deposits showed them to be composed chiefly of carbonate of magnesia and carbonate of lime.

Such deposit is chiefly to be met with in the limestone districts, or where water is drawn from wells in the red sandstone formation.

In another instance similar results were observed where this deposit was not present. It was quite evident, however, that the latter was solely attributable to excessive firing—the best Low Moor plates over the fires bulging outwards within a few days of being put in. The heat beneath these boilers was more like that of a mill furnace than that of a steam boiler, and no iron could be long subjected to it without serious deterioration. Some of these plates, at the part bulged, were reduced in thickness from ⅜ to little more than $\frac{1}{16}$in.

The loss of life resulting from boiler explosions has been rather less than in the previous year.

Mr. Longridge states in his report, that since the use of iron of inferior quality is unfortunately not unfrequent in the construction of steam boilers, an important question arises, how such dangerous boilers can best be detected. Previous to the plates being rivetted together, it is an easy matter to test their quality; and a boiler maker who neglects this precaution, and thereby endangers the lives of his fellow-creatures, is without excuse; but after a boiler is completed, there does not appear to be any satisfactory mode of testing the quality of the plates. The ordinary test, and even this is often dispensed with, viz., by hydraulic pressure, is by no means sufficient; since, when subjected to hydraulic pressure, this pressure being uniform, a boiler, though made of iron of very inferior quality, may bear the test without any symptoms of weakness. When at work, on the other hand, owing to one part being subjected to a higher temperature than another, unequal expansion is induced, which will frequently produce fracture, though the quality of the iron be unexceptionable. Of this, if necessary, abundant evidence could be given.

And we here fully endorse Mr. Longridge's opinion, viz., that *the chief protection against the use of inferior iron, in the construction of steam boilers, must be found in the employment of boiler makers of known respectability, whose regard for their reputation would be a guarantee against the use of faulty materials.*

The necessity which exists for more frequent opportunities of thorough examination, is also urged in the report, as, with comparatively few exceptions, no spare boiler is provided, and the only opportunity of thorough examination is to be found, at the annual general holidays, when more demands are made on the services of the company's inspectors, than it is possible to comply with. And, further, there prevails amongst the employers of steam power, a very imperfect idea of what is meant by a *thorough examination.* Frequently when an inspector has been sent to a mill for this special object, and sometimes at considerable expense and inconvenience, he has found on arrival, that the flues had not been swept nor the underside of the boiler cleaned; the common opinion being, that the examination of the inside of a boiler is all that is requisite; whereas many of the most serious explosions have been solely attributable to external corrosion, which could only have been detected by a careful examination underneath; a disagreeable duty too often neglected by those in charge, and for which, moreover, many men, to whose care boilers are intrusted, are totally incompetent. In proof of this assertion, it may be mentioned, in reference to one of the most serious explosions which have of late occurred, that the boiler had, within three months of the explosion, been examined by a boiler maker, who reported it in good working order, whereas, as was subsequently proved, dangerous corrosion had already taken place on the underside, reducing several of the plates to less than one-third of their original thickness, a defect which could not have escaped detection by a competent inspector.

ON THE NATURE AND MANAGEMENT OF THE SEFINET EQUATION FOR DETERMINING THE FORM OF A SHIP'S HULL.

By EDWARD SANG, C.E., F.R.S.E.

Two years ago, I read before the Royal Scottish Society of Arts,* a paper on the advantages of determining the form of a ship's hull by means of an analytic equation, and I exhibited a model which, as being the first obtained by help of a formula, well exemplified the practicability of the method.

In the present paper I propose to explain the nature of the equation made use of, and to which I have given the name *Sefinet*, from the Arabic, the word being closely allied to the German *schiff*, and to our own word *ship*, all three having the same meaning.

In this explanation, I shall not follow the course of the ideas which led me to the invention of the formula, but shall rather take one of those shorter and plainer roads which are often discovered after a result has been attained.

Having assumed any straight line AB, Fig 1, which may represent the keel of a vessel, divided it into any two portions at C, and there raised a perpendicular or ordinate CD; if we make the length of CD proportional to the rectangle under the segments AC, CB, the point D will trace out the common parabola, and the greatest ordinate will be that raised at O, the middle of AB. The geometric genesis of this curve is contained in the proportion—

$$AO\cdot OB : AC\cdot CB :: OE : CD$$

which, put in the form of an algebraic equation, is—

$$y = Y\left(1 + \frac{x}{a}\right)\left(1 - \frac{x}{a}\right) \quad . \quad . \quad . \quad . \quad (1.)$$

in which a stands for AO or OB, x for OC, Y for the greatest ordinate OE, and y for CD.

If, however, we make the square of CD proportional to the rectangle AC·CB, we obtain, as in Fig. 2, an ellipse, of which the geometric genesis is contained in the proportion—

$$AO\cdot OB : AC\cdot CB :: OE^2 : CD^2,$$

while the algebraic equation becomes—

$$y = Y\left(1 + \frac{x}{a}\right)^{\frac{1}{2}}\left(1 - \frac{x}{a}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad (2.)$$

Thus it appears that, by reducing the exponent from 1 to $\frac{1}{2}$, we pass from the sharp-ended parabola to the rounded ellipse; and so, by causing the exponent to change gradually from one value to another, we shall obtain curves of all degrees of sharpness or bluntness. Our equation, thus generalised, becomes

$$y = Y\left(1 + \frac{x}{a}\right)^{\alpha}\left(1 - \frac{x}{a}\right)^{\alpha} \quad . \quad . \quad . \quad . \quad (3.)$$

which gives the parabola when $\alpha = 1$, the ellipse when $\alpha = \frac{1}{2}$.

If, in this formula, we make α greater than unit, the curve becomes tangent to the line of abscissæ at A and B; thus, when $\alpha = 2$, the curve takes the form shown in Fig. 3; while if we make α much smaller than unit, the curve becomes blunted at the ends, as in Fig. 4, which corresponds to the value $\alpha = \frac{1}{4}$.

Let us now suppose any one of these curves to represent the water-line of a ship, corresponding to the depth z, and that a, α, and Y are functions of z, and so changeable from one depth to another, then may the whole equation represent a solid approaching, in some degree, to the form of a ship's hull.

By making α to increase from the deck dowwards, we can cause the lower water-lines to be gradually sharper than those above them; and by assuming Y to be a suitable function of z, we can obtain any required form of beam-section.

It is obvious, however, that such an equation, though containing the germ of the idea, is quite inapplicable to ships, because the greatest cross

Fig. 1.

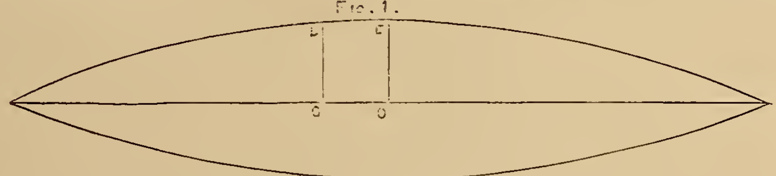


Fig. 2.

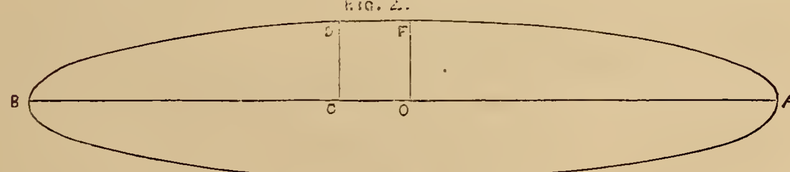
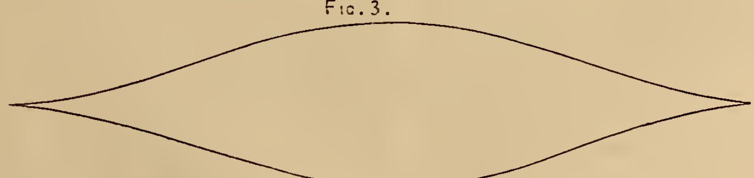


Fig. 3.



section is exactly amidships, and the fore and aft parts of the vessels are exact counterparts of each other, as is shown in Fig. 5, which represents the water-lines of some such coracle with upright stem and stern posts.

For the purpose of obtaining dissimilarity at the two ends, we may make OA and OB unequal, and may use also different indices, thus putting the equation in the much more comprehensive form

$$y = Y\left(1 + \frac{x}{a}\right)^{\alpha}\left(1 - \frac{x}{b}\right)^{\beta} \quad . \quad . \quad . \quad (4.)$$

which enables us to use any desired forms for the stem and stern posts, and also to give diverse degrees of sharpness to the two ends of the hull.

Now, if we make the ordinate CD proportional to the product of one power of CA by another power of CB, the curve so obtained reaches to the greatest distance, not opposite to the middle of AB, but opposite to that point at which AB is divided into two parts, proportional to the indices of the two powers. This is shown in Fig. 6, in which the indices α and β are in the ratio of 2 : 3.

The use of equation (4) would therefore be attended with this inconvenience, that the greatest ordinate of each water-line would happen at a place depending on the values of the exponents α and β, as well as on the distances a and b; and that, unless the proportion $a : b :: \alpha : \beta$ were to hold good throughout, there would be no proper maximum or midships frame.

To remedy this inconvenience, I multipy the value of y given in formula (4) by an arbitrary factor, and inquire what must be the nature of

* Given in THE ARTIZAN, Vol. for 1862, pp. 62, 63.

this factor, in order that the new value of y may be greatest at the point O. The result of the investigation is, that any function of x which has

$$1-\left(\frac{\alpha}{a}-\frac{\beta}{b}\right)x$$

for the two first terms of its development satisfies the prescribed condition, and thus the formula

$$y=\mathrm{Y}\left(1+\frac{x}{a}\right)^{\alpha}\left(1-\frac{x}{b}\right)^{\beta}\left\{1-\left(\frac{\alpha}{a}-\frac{\beta}{b}\right)x+etc.\right\} \qquad (5.)$$

gives a water-line of which the maximum ordinate is at O.

In this way we are at liberty to assume a, b, α, β, Y, as independent functions of z; that is, we may adopt any forms for the stem and stern posts and for the widest frame section, and may give any degrees of roundness or sharpness, and any variations of those degrees, to the ends of the ship, and yet obtain an appropriate set of horizontal sections.

The auxiliary factor of this expression is indeterminate except in its first two terms. These are fixed by the condition that the maximum frame section shall be at O. Its succeeding terms may be assumed so as to bring out other desired conditions; we may arrange them so as to give various degrees of flatness to the sides of the ship. We may propose, for example, that the sides of the ship be absolutely flat at the point E—in other words, that the radius of curvature there may be infinite; in that case, the second differential co-efficient of y must be zero when $x = o$, which happens when the third term of the auxiliary factor is

$$\left(\frac{\alpha+1}{a}\,\frac{\alpha}{a}-2\,\frac{\alpha}{a}\,\frac{\beta}{b}+\frac{\beta+1}{b}\,\frac{\beta}{b}\right)\frac{x^2}{1\cdot 2}$$

By rendering the third differential co-efficient also zero, that is, by making fourth term of the multiplier

$$\left(-\frac{\alpha+2}{a}\,\frac{\alpha+1}{a}\,\frac{\alpha}{a}-3\,\frac{\alpha+1}{a}\,\frac{\alpha}{a}\,\frac{\beta}{b}-3\,\frac{\alpha}{a}\,\frac{\beta}{b}\,\frac{\beta+1}{b}+\frac{\beta}{b}\,\frac{\beta+1}{b}\,\frac{\beta+2}{b}\right)\frac{x^3}{1.2.3}$$

we should obtain a still greater degree of flatness.

But this method of obtaining various degrees of flatness has the inconvenience of progressing by leaps, not gradually; besides, it is troublesome in the calculation. A much more convenient arrangement is to put the auxiliary factor in the form

$$\left(1+\frac{x}{r}\right)^{-\alpha}\left(1-\frac{x}{s}\right)^{-\beta}$$

in which r and s are two distances greater, respectively, than a and b, and subjected to the condition

$$\frac{\alpha}{a}-\frac{\beta}{b}=\frac{\alpha}{r}-\frac{\beta}{s}$$

which is needed in order that the maximum value of the ordinate may be kept at O.

If we suppose

$$\frac{\alpha}{r}+\frac{\beta}{s}=f\left(\frac{\alpha}{a}+\frac{\beta}{b}\right)$$

FIG. 4.

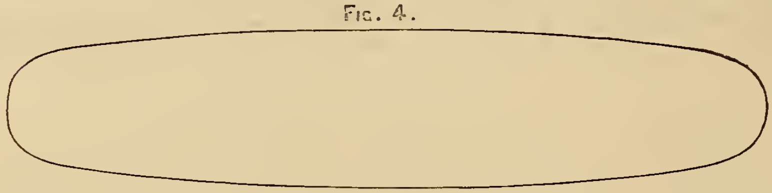


FIG. 5.

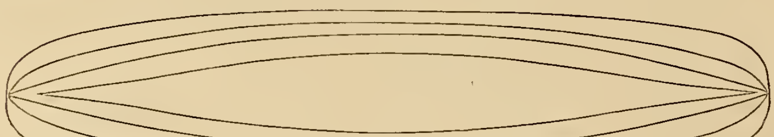
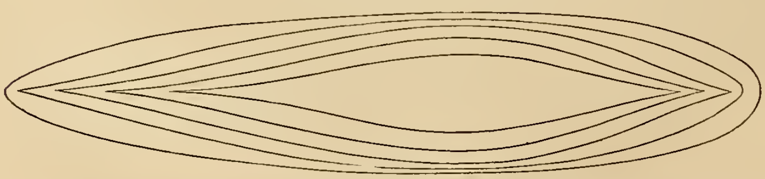


FIG. 6.



the values of r and s may be readily obtained from the equations

$$\frac{\alpha}{r}=+\frac{1+f}{2}\,\frac{\alpha}{a}-\frac{1-f}{2}\,\frac{\beta}{b}$$

$$\frac{\beta}{s}=-\frac{1-f}{2}\,\frac{\alpha}{a}+\frac{1+f}{2}\,\frac{\beta}{b}$$

in which f, a fraction always less than unit, may be called the *co-efficient of flatness.*

In this way the complete Sefinet equation may be exhibited as under:—

a, b; Y; α, β; f, being six arbitrary functions of the depth z, serving to determine—

a, the form and position of the stem post;
b, the form and position of the stern post;
Y, the form of the widest frame;
α, the character of the bow;
β, the character of the stern;
f, the degree of flatness;

then, determining r and s by the equations

$$\frac{\alpha}{r}=+\frac{1+f}{2}\,\frac{\alpha}{a}-\frac{1-f}{2}\,\frac{\beta}{b}$$

$$\frac{\beta}{s}=-\frac{1-f}{2}\,\frac{\alpha}{a}+\frac{1+f}{2}\,\frac{\beta}{b}$$

the value of the ordinate y at any part of the ship is given by the equation

$$y=\mathrm{Y}\left(\frac{1+\frac{x}{a}}{1+\frac{x}{r}}\right)^{\alpha}\left(\frac{1-\frac{x}{b}}{1-\frac{x}{s}}\right)^{\beta}\quad\ldots\quad(6.)$$

Having resolved on the outlines of the stem and stern, and fixed on the

form of the maximum frame, as well as on the position of that frame in the length of the ship, we have obtained the outlines of a solid from which the hull has to be cut. The chisels and gouges which we employ in this operation are the values of the exponents α, β, and of f, the co-efficient of flatness. With the same outlines we may have an infinity of hulls differing from each other in their characters. A few trials are sufficient to guide the naval architect in the choice of the exponents α, β, so as to realise the idea which he may have conceived of the desired shape. By making these values large we obtain sharpness; by making them small we round the form; and by causing them to change in value from the keel upwards, we can give whatever gradation we may desire. Also, by attributing to the co-efficient f various values, we may render the sides of the water-lines round or flat without changing the characters of the stem and stern, and thus we are enabled to solve the problem of obtaining accurately a given tonnage. When f is taken nearly equal to unit the sides become very flat, and if f were made unit the hull would become cylindroid.

In the model which I formerly exhibited, and now again exhibit as a first trial, and as a guide to farther attempts, the values of the various quantities were determined by the following equations, the measurements being in inches;

$$a = 35{\cdot}8 + 1{\cdot}2\sqrt{z} + 0{\cdot}2\,z$$

$$b = 37{\cdot}0 + 5\left\{\frac{2\,z}{25}\cdot\frac{50-2\,z}{25}\right\}^{20}$$

$$Y = 8 + \left(\frac{21}{20}\right)^4 + \left\{\frac{2\,z}{1+2\,z}\cdot\frac{40-2\,z}{41-2\,z}\right\}^2$$

$$\alpha = 2{\cdot}0 - \frac{1}{10}\,z$$

$$\beta = 1{\cdot}6 - \frac{1}{10}\,z$$

$$f = 0{\cdot}4$$

while the equation of the sheer-line, as applied to the edge of the rail, is

$$Z = 12 + \frac{3\,x^2}{6400} - \frac{x^3}{256000}$$

the gunwale being 2 inches below the rail.

INSTITUTION OF CIVIL ENGINEERS.

PRESIDENT'S ADDRESS.

The following address was delivered by J. R. McLEAN, ESQ., F.R.S., President of the Institution of Civil Engineers, on taking the chair, for the first time, after his election, January 12, 1864:—

GENTLEMEN,—The greatest honour a civil engineer can attain is to become the President of this Institution, and I beg to thank you for having, by your suffrages, placed me in that distinguished position.

I feel deeply the responsibility of presiding over an institution, comprising, as it does, upwards of one thousand members and associates, gentlemen who personally represent every branch of civil and mechanical engineering and practical science, and amongst whom there are so many better qualified than I am to occupy this chair. But as you have not considered it necessary to depart from the custom of electing your senior Vice-President to the important office of President, I will accept the trust, and endeavour, with your continued support, to discharge conscientiously the duties connected with that office.

My first duty is to address you on assuming the chair, and I will now claim your attention to the few general remarks I have to make.

The progress of engineering science has been so fully recorded by my distinguished predecessors in office, that I propose on the present occasion, instead of describing any engineering works, to point out the extraordinary effects these works have exercised, during the last thirty years, in promoting the material and intellectual progress of Great Britain, and increasing the comforts and social enjoyments of all classes of its inhabitants. I will endeavour to show that the wonderful prosperity attained during that period is to be attributed mainly to our railway system, which has enabled us to develop the mineral resources of the country, and at the same time to provide secure and reproductive investments for the profits realised by the successful working of the system.

It is a prevalent opinion, that the increased prosperity of the country, to which I refer, has been the result of improvements in the cultivation of the land, better drainage and farming, and in consequence of the railway system having provided better means of access to markets and places for disposing of the products of the soil, and obtaining suitable materials for renewing its fertility. In order to show the incorrectness of this opinion, it will be necessary to refer to the reports of the Commissioners of Inland Revenue, which give returns of the property and income of Great Britain, at two different periods especially suitable for the comparison I wish to make; one before the works of the civil engineer had attained much importance, and the other after the successful application of the steam engine to locomotive purposes had led to the construction of our present magnificent system of railways.

The years selected for the purpose are 1815 and 1856, the return of the property and income of the country being fully given for those years in the reports of the commissioners. Besides, the year 1815 was the last year of the income tax in which accurate statistics can be obtained of the property and income of Great Britain. It was also the last of a long series of years of war, during the whole of which the property and income tax had been in operation; and, as the financial necessities of the Government were great, we may safely accept these returns as accurate, and rely that no source of income, or property, which could be brought within the operation of the Chancellor of the Exchequer, has been omitted from the account, and allowed to escape taxation. It was, moreover, a period in which most of the great discoveries of the engineer, except the locomotive engine, were in full operation. The steam engine, as improved by Watt, had been in operation forty years before, pumping water from mines, raising minerals, and providing motive power; and Arkwright and other great inventors had perfected the machines employed in textile manufactures, and had brought them into general use.

In the returns referred to we find each source of income under a separate head; and, in order to make the comparison as simple as possible, I take in all cases the amount of the tax under that head as the measure of the value of the property or income assessed, as set forth in the following Table:—

TABLES OF THE NET AMOUNT OF THE PROPERTY AND INCOME OF GREAT BRITAIN, FROM ALL SOURCES, LIABLE TO ASSESSMENT FOR TAXATION IN THE YEARS 1815 AND 1856.

TABLE No. 1.—YEAR 1815.

LAND:—	
Land, Tithes, Manors, Fines	£41,521,492
HOUSES (exclusive of farmers' houses)	16,259,400
PROFITS ON REALIZED PROPERTY:—	
Quarries, Mines, Ironworks, &c.	1,452,104
Farmers' profits	21,762,280
Funds	30,048,620
Profits of trade and professions	30,211,880
Government departments	11,132,450
Total	£152,388,226

Incomes and profits exempt under £50 per annum during this year.

TABLE No. 2.—YEAR 1856.

LAND:—	
Land, Tithes, Manors, Fines, Fisheries	£38,153,935
HOUSES (exclusive of farmers' houses)	48,435,585
PROFITS ON REALIZED PROPERTY:—	
Quarries, Mines, Ironworks, Canals, Railways, Gasworks, And other property	18,087,963
Farmers' profits	24,224,443
Funds	24,407,360
Profits of trade and professions	74,551,046
Government departments	14,607,036
Total	£242,467,368

Incomes and profits exempt under £100 per annum during this year.

In Table No. 1 we find, that in the year 1815, or forty years after the steam engine had been improved and used for saving labour and producing motive power in connection with mining and manufactures, the whole annual income derived from quarries, mines, ironworks, and other property was only £1,452,104.

In Tables No. 1 and 2, we find the net income available from taxation, derived from land, and the profits of the farmers, taken together, in 1815, to be £63,283,772; whilst in 1856, it was only £62,378,378.

The net income derived from houses during the same period, had increased from £16,259,400 to £48,435,585, an augmentation of £32,176,185, or nearly three hundred per cent.

The net profits derived from mines, quarries, ironworks, canals, railways, and other profits, had increased from £1,452,104 in 1815, to no less a sum than £18,087,963 in 1856, or upwards of twelve hundred per cent.

From these figures we learn that during the forty years over which the comparison extends, the profits and income of land together had not increased, notwithstanding the construction of roads, railways, canals, and other public works, and the relief from poor-rates afforded to it by the extension of the rate on other property, and by the absorption of the increased population in new occupations (as shown by the population returns), the number of labourers employed on the land at the census of 1861, being less than in the year 1815. No doubt the condition of all classes connected with the land, including the landlord, farmer, and agricultural labourer, had improved during the period in question, and much capital had been expended in farm-buildings, drainage, and machinery. Yet the net annual income available for taxation in 1856, derived from land and farmers' profits, was not greater in 1856 than in 1815, although the income derived from all other sources of property, during the same period, had largely increased, as we find in the Tables,—the net amount of income derived from the profits of trades and professions available in 1815, being £30,211,880, and in 1856, £74,551,046, showing an increase in the latter year of nearly 150 per cent., the exemptions from Income Tax being under £50 per annum in 1815, and under £100 in 1856.

In these Tables we also find the total net amount of income derived from all sources available for taxation in 1815, to be £152,388,226, and in 1856, £242,467,368, showing an increase of sixty per cent., or upwards of £90,000,000 (which, on the basis of the taxation of 1815, would have yielded £9,000,000 additional tax), from sources independent of the land.

I will now attempt to point out the causes of the enormous increase of the income of Great Britain, shown by the Tables, representing the profits of many hundreds of millions sterling invested in railways, canals, mines, ships, and other works, in this country, in India, and in our colonies.

Fortunately the railway system, since the introduction of the locomotive engine, improved by Stephenson, gave it vitality, has been a complete success, in the reproduction of capital, in the enormous saving in the cost of transport, and in the facilities it affords for the development of mines, and of nearly all branches of national industry.

After the opening of the Manchester and Liverpool Railway, the accumulated wealth of Great Britain, which, previous to that time had been but sparingly invested in public undertakings, and was for the most part hoarded, or placed on doubtful securities, was thrown lavishly into the railway system; and, although for a time this led to the belief, that the supply of capital for the construction of such undertakings was inexhaustible, and induced excess of speculation, temporary distress, and subsequent distrust in the system; yet the progress of railways ever since that period has been steady, and a reproductive profit has been assured on a capital of nearly £400,000,000. This vast capital has been created because railway securities, on the principle of limited liability, occupy the highest place in public estimation, for investing the realised profits of the country, in consequence of the facility with which they can be purchased, and transferred in amounts suited to the requirements of every class of society; and this leads to a constant accumulation of capital by inducing people to save a portion of their income—not merely for their own support in an after-period of life, but for the benefit of their descendants. Thus railway securities afford the means of transmitting wealth, as printing does knowledge, from one generation to another.

The beneficial effects of the railway system has not been confined to Great Britain. Before the introduction of railways the land was nearly the only safe means in Europe for the investment of capital; and, in consequence of the competition for this security, the interest was reduced to a minimum rate, and was barely sufficient to induce people to save a portion of their income. The construction of railways, by inducing saving, has established a weathy and educated middle class in most countries in Europe, who have not only developed the industrial resources and increased the capital of the country to which they belong, but have also, as in this country, promote education, and humanized the conduct of all classes of the people.

I have only one more remark to make on railways as a cause of the increase of wealth. The land occupied by railways in Great Britain is under two hundred thousand acres, including stations and other conveniences, and to obtain possession of this land it has been necessary, during every session of Parliament, for the last thirty years, to engage the services of the ablest counsel, and the most eminent engineers in the committee rooms of both Houses at an incalculable expense. The land used for agricultural purposes is about forty million acres, and yet the railway system, occupying only about one half per cent. of the total area of the land, now pays nearly as great an amount of income and property-tax as is paid by the whole of the farmers of Great Britain.

Another source of wealth is the great deposit of coal, and iron, stone, and other minerals—in nearly every part of the kingdom.

The most important of these is coal. The quantity of coal raised in Great Britain is now about one hundred millions of tons yearly, produced by the labour of about three hundred thousand men.

We are indebted to Professor Liebig, the celebrated German chemist, for data by which we can estimate the value of this enormous quantity of fuel, by comparing it with wood, or other produce of the soil.

Liebig informs us, that every acre of fertile land will produce yearly about two tons and a half of wood, or other crop, which contains about the same quantity of carbon (80 per cent.) as one ton of coal. The one hundred million tons of coal now raised annually from our mines contain about eighty million tons of carbon; and to produce the equivalent of this in wood would require one year's growth of, in round numbers, one hundred millions of acres of land—an area about four times larger than the arable and pasture land of England (which does not exceed twenty-five million acres), and as nearly as possible equal in extent to the area of the kingdom of France. Yet this supply of fuel, even if it existed in the form of wood, would be practically useless as a substitute for coal; the labouring population of the kingdom would be unable to cut and convert it, the whole of our railways and canals would not suffice to transport it, while the cost of these operations, if no other obstacle intervened, would prevent them from being carried on beneficially.

The development of coal, then, is mainly the cause of the increase of wealth, but if railways had not proved reproductive investments, this mineral would have added little more to the wealth of Great Britain than it did in 1815, as shown by Table No. 1.

The serious question as to the permanence of this fuel, on which the wealth of the nation so much depends, has been prominently raised. Since the great discovery of Murchison that coal underlies, and may be found with reasonable certainty under the lower red sandstone and permian formations, which extend over millions of acres of Great Britain; and, if beneath them, at greater depths, under all the measures which overlie the permian, and which, together, comprise upwards of one half the area of Great Britain we may consider our coal mines to be practically inexhaustible, and that we have not to fear any deficiency in quantity, arising from the exhaustion of the mineral, but rather the practical difficulty of obtaining it from a great depth below the surface, in consequence of the central heat of our globe, which, it is alleged, will ultimately, and within a defined and not distant period, reduce the production to a limited supply.

Much may be said in support of the theory of central heat, but I think undue importance has been given to it, as a difficulty in mining operations. A comparatively thin coating of clay, or fire-bricks, surrounding a blast furnace filled with molten iron, affords such protection that the hand may be placed without inconvenience on the outer surface of the brick-work, and it is difficult to understand how any internal heat can penetrate through the crust of the earth—estimated to be thirty-four miles in thickness—so as to interfere with the temperature at the comparatively small depth from the surface at which mining operations are carried on. I am of opinion that the heat, which undoubtedly exists in some mines, arises, not from central heat, but from superincumbent pressure, and defective ventilation. The gases in the coal are highly compressed, and, when liberated by mining operations, are at a high temperature; but we know that with large shafts, air may be conveyed to any depth that has yet been reached in mining operations, without in the slightest degree altering its temperature; and that by a proper enlargement of the air passages, air descending the shaft may be distributed through the workings, so as to lessen the liability of accident from explosion, or serious inconvenience from heat, at any depth to which shafts can be sunk. The system of sending compressed air down the shaft by means of water is found to abate inconvenience in deep mines owing to an excess of temperature.

I therefore think that the time when we shall experience a want of coal, arising from exhaustion, or from difficulties occasioned by depth of the mines, or an excess of temperature, need not at present in any way influence our conduct in the development and use of that important mineral; especially as the power (which is the substitute for labour) derived from coal is so cheap, that we are enabled to consume daily for our domestic comforts, for machinery in the conversion of minerals, and for other manufacturing processes, and for export, a power equal to twelve millions of horses, at a cost, at the time, of not more than one penny per horse-power, working ten hours a day, and no saving in consumption of this enormous quantity of coal can be made, except by employing more expensive labour as a substitute.

With this power at our command the cost of sinking to, and of raising minerals from the greatest depths, is inappreciable; while the intrinsic value of coal when compared with any other fuel, is so great that it may be

drawn profitably from almost any depth—the only limit being the strength of the machinery and materials required to raise it.

The next mineral of importance is ironstone.

In the year 1862 the production of ironstone and iron ore in the United Kingdom amounted to 7,586,956 tons, which, by the operation of five hundred and sixty-two blast furnaces, was converted into 3,943,469 tons of pig iron.

The importance of the iron and coal trade as a source of wealth is proved by the fact that the declared value of the iron and coal exported from this country during 1862, either in raw, or a manufactured, or a partially manufactured state, was nearly £25,000,000, due altogether to the development of our natural resources; and this sum represents the cost price only, and is exclusive of carriage, or freight and profits of trade, which may fairly be taken to represent one half more.

In 1862 our other mines produced the following quantities of minerals, viz.:—

Tin ore	14,127 tons.
Copper ore	224,171 „
Lead ore	95,311 „
Zinc (blende)	7,497 „
Pyrites (sulphur)	98,433 „
Salt	981,598 „
Fire-clay, china-clay, and porcelain stone	853,803 „

These minerals, and the metals produced from them by means of coal, have enabled us, with the assistance of the shipping interest, to obviate, to a great extent, the effects of the failure in the supply of cotton; for notwithstanding the great decrease of the export of cotton goods (to the extent of £10,000,000 in the year 1862), the total amount of exports during the financial year just ended (1863) has been £124,137,812, exclusive of carriage and freight, and we have thus been enabled to pay for all imports, and partially to alleviate the distress among the cotton operatives in Lancashire.

I will not occupy your time in detailing all the various profitable employments which result from mining and manufacturing operations, but will only refer to, perhaps, the most remarkable of them—shipbuilding.

The Government returns for 1861 show, that in that year 975 ships, representing 200,839 tons, were built and registered in the United Kingdom—of these 91,095 tons were constructed of iron, the average of the iron vessels being a burthen of 430 tons each.

And this, it should be remembered, is inclusive of iron ships built in private yards for the Royal Navy, and of the ships constructed for foreigners.

The iron screw steamships, in consequence of their great and regular speed, due to engineering skill, have practically become an extension of the railway system, over all parts of the world, and have enabled us more freely to exchange the products of our industry for those of other nations, thereby conducing to the employment, the intellectual and social enjoyment, and the convenience of the people, and providing for the further increase of population and universal wealth.

On these considerations I am justified in stating, that the increase of the income of England since the year 1815, has not arisen from the land; but that is mainly due to the discoveries of our great engineers. There remains still to be considered the question of the distribution of this wealth, which has been the means of providing profitable employment for millions of a rapidly increasing population who, but for such industrial undertakings, must have remained a burthen on the land, and a cause of poverty and discontent; unless reduced in number by famine, or by extensive emigration.

The Tables I have given show that the wealth has been fairly distributed among all classes of society, and that while the "rich have been growing richer, the poor have become less poor;" and that the "wide interval that formerly separated the extremes of wealth and poverty" is being gradually closed, not by the reduction of wealth, but by the diminution of poverty, arising mainly from the mining and industrial sources which I have described.

We may also congratulate ourselves that this wealth has not been employed in reproductive undertakings alone, but that the great cause of education has felt the stimulus of it, and that every year the importance of developing and directing the intelligence of the people is more distinctly recognised.

I will now make a few remarks on the extension of the railway system, and especially on the construction of the proposed new lines in the metropolitan districts. It is evident that parliamentary sanction will not be given to all the lines which have been suggested, but the convenience of the public, and the necessity for relieving the streets from the heavy traffic passing to and from the present railway stations, require that some of these lines should be constructed without delay. The success of Mr. Fowler's Metropolitan Line, due to the talent exhibited in its construction, as well as to the tenacity of its promoters in overcoming all difficulties—those of finance not being the least—has proved that railways in the metropolis can be made a source of profitable investment.

Much has been said as to the destruction of property which, it is assumed, will result from the execution of the proposed metropolitan extensions, and the question has been discussed, as if the property taken were wasted or destroyed, forgetting that is only a change of occupation, and that the house pulled down will, in many cases, be much better restored, in accordance with modern sanitary improvements, or the sites will be applied to more profitable uses, tending to the general improvement of the metropolis, the convenience of the public, the relief from local taxation, and the better occupation of the working-classes.

The construction of these railways, by means of private funds, is less objectionable than by funds derived from a tax on the coal and wine dues, or any other mode of local or public taxation. If public funds were to be resorted to, the works now so much needed would never be executed, as the enormous capital required would prevent either local boards, or the Government itself from undertaking them. Besides, it is only right that those who use these railways should pay for them, and not people living remote from the metropolis who may never enjoy them.

Occasionally unproductive works of national importance, such as the Thames Embankment, may be executed at the public expense, but the principle of Government construction is inadmissible in this country, in the case of railways or any other public work which can be rendered reproductive by private enterprise.

In consequence of the great interest now evinced in the progress of the works of the Isthmus of Suez Canal, and as the subject has never been brought directly under the consideration of the Institution, I will take this opportunity to make a short statement respecting the labours of the English members of the International Commission, who in the years 1855 and 1856, examined the question of the practicability of forming a ship canal through the Isthmus of Suez.

In the year 1855 M. Ferdinand de Lesseps, acting for H.H. the late Said Pacha, Viceroy of Egypt, invited me with the late Mr. Rendel, and your Honorary Secretary, Mr. Manby, to form part of an international commission, for the purpose of considering and reporting on the practibility of forming a ship canal between the Mediterranean and the Red Sea, and the best mode of constructing it, and for that purpose I accompanied M. Conrad, of Holland, MM. Rénaud and Lieussou of France, and M. de Négrelli of Vienna, to Egypt in that year. The commission was an honorary one, and we were considered the guests of the Viceroy from the time of our leaving Marseilles to our return to Europe.

In Egypt we met M. de Lesseps, Mougel Bey, and Linant Bey, engineers, and other gentlemen in the service of the Viceroy, and in the months of December, 1855, and January, 1856, we made a careful examination of the harbours in the two seas, which it was proposed to unite, and of the desert lying between them, and arrived at the conclusion, that a ship canal was practicable between the Gulf of Pelusium in the Mediterranean and the Red Sea, near Suez. Thus far we are all agreed, but we differed as to the mode of construction. The English members were of opinion that a ship canal raised twenty-five feet above the sea level and communicating with the Bay of Pelusium at one end, and the Red Sea at the other, by means of locks, similar to the sea entrances of the Caledonian canal, might be constructed, there being no difficulty in abundantly supplying the canal, at all times, with water from the Nile, by a cut made from a suitable level, without depending in any way on the closing of the "Barrage" of the Nile. The foreign members of the commission were, however, of opinion that a canal twenty-seven feet below the sea level from sea to sea, without any lock, was the best system, with harbours at each end, one to be constructed in the Mediterranean by piers and dredging, and the other in the Red Sea by dredging to the deep water, which in both seas is at a considerable distance from the shore.

On a comparison of the two systems it was found that the ship canal above the sea level, with locks, would save many millions of cubic yards of excavation, principally dredging, a difficult and expensive operation, and would involve no more than the ordinary contingencies which might attach to any similar engineering work of equal extent, while the difficulty arising from rocks at Suez, and running sands at Pelusium would be avoided, and a large sum of money saved in the cost of construction, by employing locomotive engines instead of human labour.

The English members also considered this system the best for the shareholders, and most calculated to give productive returns for the capital invested.

The whole of the members of the Commission [see Appendix], with the exception of Mr. Rendel, met at Paris in June, 1856, when the report of the English engineers, signed by Mr. Manby on their behalf [see Appendix], was presented, and after full discussion, was rejected by the foreign members of the Commission, who preferred a canal without locks; and, as they formed the majority, the report to H.H. the Viceroy recommended the system now actually in course of construction.

As the English engineers were members of a purely honorary Commission, their labours terminated with the report.

Five years after the discussion in Paris of the mode of construction by the International Commission, your past president, Mr. Hawkshaw, was requested by H.H. the late Viceroy to "examine the site of the proposed ship canal, intended to connect the Red Sea and Mediterranean, across the Isthmus of Suez, and to report his opinion of that work." In February, 1863, he made a very able and elaborate report, which details the actual progress of the ship canal and its accessories, up to the end of the year 1862, constructed in accordance with the system adopted by the majority of the Commission, from which it appears that they had been executed of the ship canal (principally dry earthwork) six million cubic metres out of ninety-six millions, or one fiftieth part of the whole—the expenditure up to that period, including the partial execution of the fresh water canal, being £1,200,000—leaving to be excavated ninety millions of cubic metres; or twenty millions of cubic metres more than the entire quantity required to complete the canal according to the system proposed by the English members of the Commission,

I will now address a few remarks to the junior members as regards the future prospects of the profession.

I have shown that, during the last thirty years, the works of the engineer, or those executed under his direction, have led to the present prosperous condition of Great Britain—and by the extent of the works that have been done during that time we may fairly measure those that are yet to follow. The extension of the railway system is necessary for the progress and well-being of the world, and must be carried out by our young engineers in this country and in every part of Europe, in India, and in our colonies. There is no country that will not become richer by the introduction of railways, and the richer a foreign country becomes the more it adds (by the extension of commerce) to the wealth and prosperity of this kingdom. And, if our railway system is extended, new harbours, docks, canals, steam ships and other engineering works will be necessary to meet the requirements of traffic and the demands of increasing commerce.

Nothing but unwise legislation, and the imposition of restrictions on commerce, for which happily the public mind is not prepared, can prevent the progress of those great works—unless the railway system become a "protected interest," which would be disastrous to all mining and manufacturing undertakings, which mainly depend for their prosperity on the further development of the system; and also to the public, who would be deprived of their safest and best security for the investment of their annual savings. If railway companies were relieved from the risk of competition, instead of making new lines to meet the requirements of trade, and the wants of an increasing population, they would probably, with the view of improving the value of their shares, consider their best interest lay in imposing higher charges, and giving only limited accommodation to the public.

In conclusion, I hope the day will arrive when the basis of fixed taxation will be so extended as to enable the Government to abolish all our Customs duties, nearly the last restrictions on commerce which limit the free exchange of traffic between ourselves and other nations, and when free intercourse will be permitted to be carried on by railways and steamships, as part of one system, without interruption at the sea ports, and without the impediments and waste of labour and expense occasioned by the intereference of bonding warehouses and Government officials, required under our present system of taxation.

APPENDIX.

Isthmus of Suez Canal.

Comparative advantages of the two systems, proposed for constructing a direct canal between the Mediterranean and Red Seas.

FIRST SYSTEM.

(*Adopted by the* majority *of the Commissioners*)

The level of the top water of canal to be the same as the level of the low water of the Mediterranean Sea at Said.

SECOND SYSTEM.

(*Proposed by the English Members of the Commission*)

The level of the top water of the canal to be 7 metres above the low water of the Mediterranean Sea.

In each case the canal to be 8 metres deep, and to have the internal slopes in cuttings 2 to 1, and in embankments 3 to 1. The width of the bottom in all cases to be 68 metres.

LOW LEVEL.

The total quantity of excavation will be 130,000,000 cubic metres. One-half of that quantity below the natural drainage of the country will require to be dredged.

The method proposed of forming a small canal first, and afterwards enlarging it, is impossible, unless Lake Timsah and the Bitter Lakes are avoided. The stone found in the cutting cannot be made available for the harbour of Said, until the canal is opened throughout.

The difficulties arising from stone and running sand, forming part of the material, may be great; the former at Suez, the latter in Lake Menzaleh.

HIGH LEVEL.

The total quantity of embankment will not exceed 70,000,000 cubic metres, and may be much reduced by a judicious selection of the line of canal.

The whole of the excavation will be above the natural drainage of the country, and may be conveyed with great rapidity into embankments, by means of railways and locomotive engines.

The stone found in the cuttings and in the ground adjoining El Guisr, may be used for the harbour of Said.

The difficulties will not be greater than in an ordinary engineering work.

HARBOUR OF SUEZ. (First system)

There will be considerable difficulty in forming a channel 400 metres wide and 3,000 metres in length, by dredging engines, and every probability of meeting with coral reefs and indurated sands, or conglomerate, similar to the rocks at Suez.

HARBOUR OF SUEZ. (Second system)

The canal may be carried round the Bay of Suez, in the manner shown upon the chart, and the locks formed in deep water, which will avoid the necessity of dredging, and all the risk attendant upon it.

There will not be any necessity for jetties, as the harbour is completely sheltered, except from the north wind, and the embankment of the canal will afford ample protection.

The canal will be close to the quarries of Attaka, an object of great importance in the execution of the works of the canal and harbours.

PORT TIMSAH. (First system)

The cost of establishing a port in Lake Timsah will be considerable, and much dredging will be required.

PORT TIMSAH. (Second system)

The high level will save the cost of the locks at this point. The maritime canal and the branch canal to the Nile will be on the same level, and great expense will be avoided in the construction of wharves and other works.

Between the Nile and the maritime canal only two, or three regulating locks will be required.

IRRIGATION. (First system)

A canal is proposed between the Nile branch canal and Suez, for the purposes of irrigation and fresh water supply, and a conduit from the same branch to the Mediterranean, for similar purposes. Steam-engines of 500 horse-power, at a working cost of £27,000 per annum, are to be erected.

IRRIGATION. (Second system)

The canal and conduit may both be avoided by adopting a higher level, and supplying the canal from the Nile below the the barrage. Irrigation may be carried on much more advantageously for the whole distance between Suez and the Mediterranean Sea, by supplying the maritime canal with fresh water, and using it as a great reservoir, during the inundations of the Nile (which would be impossible in a conduit).

The whole of Lake Menzaleh may be reclaimed.

SUPPLY OF WATER. (First system)

The canal will depend for a supply of water on tides of the Red Sea.

Unless there is a current out of the Bitter Lakes, as well as into them, the evaporation of 5,000,000 cubic metres of salt water daily, during three months in the year, will form deposits; as nearly 3 per cent. of salt will be deposited after a certain time, or 150,000 cubic metres daily.*

At the present time the water is salter at Suez than in the Pacific, and were it not for the constant outgoing current of brine at Babelmandel, the Red Sea would fill up with salt.

The tidal observations do not give the simultaneous condition of the

SUPPLY OF WATER. (Second system)

The supply of water will be direct from the Nile at its lowest level, and be regulated by locks during inundations.

There will not be any possibility of failure, either from winds or from scarcity, during dry seasons; the minimum discharge of the Nile being 50,000,000 cubic metres per hour.

The abstraction of 1-24th part of the water of the Nile during low-water time, and 1-30th part during inundation, will provide for loss of water, by evaporation and leakage, and for an average lockage of 100 vessels daily.

The deposit of the limon of the Nile will take place in the branch canal, and may be removed annu-

* *Vide* Maury, "Physical Geography;" and Lyell, "Elementary Geography," p. 347.

tides at Suez and in the Mediterranean, nor the variation during each half-hour of low and ebb, so that it is impossible to estimate the velocity of the currents through the proposed canal.

One great difficulty will be to fill the Bitter Lakes.

If the sea is freely admitted, the velocity into the lakes, even at low water, will be 6 feet per second, which would completely destroy the channel.

Even supposing them to be filled, the tides will barely be sufficient to supply the waste arising from evaporation and absorption, and a current will flow from both seas, until the channel gradually becomes filled up.

ally, without interfering with the navigation; or it may be sent down the maritime canal to sea, by scouring, in a particular method devised for that purpose.

HARBOUR OF SAID.

Two jetties, one 3,000 metres, and the other 2,500 metres in length, will have to be constructed, and the space, 400 metres between, dredged and conveyed away in barges.

The stone must be brought from the islands in the Mediterranean Sea.

No dredging can take place until a temporary harbour has been constructed, as it is a lee-shore during nine months of the year.

There will be no back-water to keep the channel open; on the contrary, there will be a gradual flow into the canal, which will tend to form a new beach in the harbour and canal.

There will be no certainty that the work will ever be finished. It will altogether depend on contingencies, over which the engineer has no control, and which cannot be estimated.

HARBOUR OF SAID.

The locks and harbour may be constructed without more than ordinary difficulties, and no dredging will be required except at the tail of the lowest lock.

The stone from El Guisr may be used in the harbour, as a railway will be required for constructing the banks.

The scouring power of the water will always keep the channel open.

The contingencies will not be greater than usually belong to works of this magnitude.

Therefore, under the first system, the construction may be regarded as impracticable, whilst under the second system it may be considered feasible.

Approved by
J. M. RENDEL and J. R. McLEAN,

And signed by
CHARLES MANBY,
For the Members of the English Commission.

The International Commission was composed of the following members, viz.:—

M. F. W. CONRAD	Chief Engineer of the Water-Staat, the Hague.
CAPTAIN HARRIS	Of the Honourable East India Company's Navy, London.
CAPTAIN JAURES	Of the Imperial Marine, and Member of the Council of the Admiralty, France.
M. LENTZE	Chief Engineer of the Works on the Vistula, Berlin.
M. LIEUSSOU	Hydrographical Engineer to the Imperial Marine of France, Paris.
MR. J. R. McCLEAN	Civil Engineer, London.
MR. CHARLES MANBY	Civil Engineer, London.
M. MONTESINO	Director of Public Works, Madrid.
M. DE NEGRELLI	Inspector-General of Railways in the Austrian Empire, Vienna.
M. PALEOCAPA	Minister of Public Works in the Kingdom of Sardinia, Turin.
M. RENAUD	Inspector-General and Member of the Council for *Ponts et Chaussées*, Paris.
MR. J. M. RENDEL	Civil Engineer, London.
M. RIGAULT DE GENOUILLY	Rear-Admiral of the Imperial Marine of France, Paris.

ON THE CLOSING OF RECLAMATION BANKS.

By MR. J. M. HEPPEL, M. INST. C.E.

The chief objects of the paper were to bring clearly into view, the circumstances which determine the velocities of influx and efflux, and consequent scour, attendant on the closing of embankments for reclaiming land from the sea, or a tideway, and constituting the chief difficulty to be overcome in executing such works.

It was shown, by an easy geometrical process, curves might be constructed, which would indicate correctly the difference of the levels of the exterior and interior water surfaces, at any given interval of time from low water; the data for their construction being the rise of the external tide water, the areas of the interior surface at the several successive levels, and the width of opening through which the flux and reflux took place.

It was contended that, in most cases, it would be better, and a safer practice, to determine in the first instance, by such means, the requisite width for the final closing place, and to construct it in such a way as to ensure its capability of resisting the scour to which it would become exposed, than to leave the closing arrangements till the banks had already advanced so far as to have given rise to considerable outward and inward current; as it was argued that, if this were done, the carrying up of the banks to each side of such final closing place would be effected with ease and certainty; and the preparations for final closing, having been made from the commencement, could also occasion no unforseen difficulty; and that thus the whole operation would be brought more within the province of precise calculation, and adaptation of means to the required end, than according to present practice it usually was.

THE EAST COAST, BETWEEN THE THAMES AND THE WASH ESTUARIES.

By MR. J. B. REDMAN, M. INST. C.E.

The object of this paper was chiefly to describe the peculiarities of the East Coast from the Thames to the Wash, including the well-known formations termed Nesses, caused by the constant abrasion of the neighbouring cliffs, due to the influence of wind waves, produced by gales from the N.E. acting on the large area of the North Sea. A similar paper was read in 1852 (Minutes of Proceedings, Inst. C.E., Vol. xi., pp. 162-204), describing the South Coast, from the Thames to Portland: the leeward motion in that case being up channel, due to the influence of S.W. winds, the resultants being, the well-known shingle formations of the Chesil beach, Portland, Hurst beach, at the entrance to the Solent, Portsmouth beach, Brighton beach, which was the site of the town in the time of Elizabeth, subsequently destroyed by the sea, Langley Point, formed under Beachy Head, after destruction of Old Brighton, and which shut up the old haven of Pemsey, or Pevensey, now a mere drainage outfall, Dungeness, stretching four miles into the sea, beyond what was the coast line at a comparative modern historic period, and which had increased, as Langley Point to the West had decreased, subsequent to its maximum protrusion. The alterations of the beach eastward at Dover and Deal, and its subsequent deposition beyond Sandown, where such remarkable alterations had occurred of late years, involving the demolition of Henry VIII.'s Castle, at Shingle End, were traced; Shingle End, as its name implied, being the leeward resultant of the beach travelling up channel from the westward, diverting the course of the Stour, extinguishing the Roman ports at Richborough and Reculver, and assisting in closing up the estuary between the main land and the Isle of Thanet.

On the east coast Landguard Point might be regarded as the shingle end of the eastern beaches, whose leeward motion was the reverse of that of the beaches of the English Channel, threatening, as it did ultimately, the very existence of Harwich Harbour as a deep-water port. The alterations of this remarkable formation were traced, illustrated by drawings from the Cotton MSS. of the time of Henry VIII., and a description was given of the peculiar position of the serial belts of shingle "fulls" formed, at a remote period, parallel to the shore, and those of a modern date, intersecting the former, at an acute angle, sweeping round in a S.W. direction, and travelling across the harbour entrance. It was inferred that, at a remote period, the outfall waters of the Stour and the Orwell flowed seaward in a more easterly direction, under the main land, being diverted gradually to the west, by the prolongation of Lunger, or Landguard Point, which at one time had a more direct south extension seaward. The pier, erected a few years since, on the west side of the harbour entrance, to confine the outfall eastward, had not any influence in arresting the march of the shingle westward. The local wasting both on the east and the west sides, involving the partial destruction of the military graveyard eastward, and the outworks of the fort, westward, and the extension of the Point, S.W., were alluded to as a thinning process, resulting in such an alteration of the outfall channel as to induce the Trinity Corporation to abandon the lights established in 1818, and to substitute others at Dovercourt. The present condition of Harwich, as a national harbour, was one worthy of serious consideration, for, coincident with the rapid abrasion of the light tertiary cliffs, and their retreat landward, from the Naze to the Colne, constantly proceeding, so might a continued extension S.W. of Landguard, parallel to the shore, the same as at Orfordness, be looked for. Felixstow and Bawdsey beaches were described, and also the extraordinary formations of Orford, Orfordness, and Aldborough, together 10 miles in length. It was shown by drawings from the Cotton MSS. of the time of Henry VIII. and of Elizabeth, that the outfall at Orford was, during the reign of the first-named monarch, opposite Orford Castle, 4 miles N.E. of the present outfall, and indications of the ancient haven might be traced in the undulations of the shingle at the present day; the progressive S.W. extension of the shingle being defined by overlapping horns, termed locally North Weir Point, or North Ear Point, from the resem-

blance of the terminal shingle at the outfall to the human organ. A local modern variation of the Ness was described, involving an alteration of the lights, caused by a local northern decrease and extension eastward, similar in character to that described in 1852 as occurring at Dungeness. Aldborough beach and the former greater extent of the town eastward were described.

Landguard beach	......	2 miles	by ¾ mile.	
Felixstow do.	......	3 do.		
Bawdsey do.	......	5 do.	by ¼	„
Orford do.	......	5 do.	by ¼	„
Orforduess	......	2 do.	by ⅔	„
Aldborough do.	......	3 do.	by ¼	„
		—		

Formed a belt of 20 miles of continuous shingle.

The great abrasiou at Dunwich and uorthward had formed the materials for these marine alluvion. Southwold, as shown by a drawing of the time of Henry VIII., from the Cotton MSS. of Southwold, Walberswych, and Dunwich, was a large tidal estuary, with two arms covering the present marshes of those names; but even then, before the enclosure of the marshes, to which had been attributed the subsequent modern deterioration of the port, in the inquiry before the Tidal Harbours Commissioners of 1845, it was shown to have beeu as bad, by historic evidence, as at any subsequent time. Lowestoft Ness had grown out subsequent to the erection of the church in the fifteenth century; the great extension of trade due to the formation of the harbour and the introduction of capital, and the admirable natural roadstead formed by the outlying sands, the extension of which southwards, the closing up in some cases of intervening swatchways or gatways, and the abrasion of the N. heads of these outlying sands, forming Yarmouth and Lowestoft Roads, were referred to, instanced by recent alterations of the lights by the Trinity Corporation; and this variation, by local estimation of pilots and others, amounted to as much as 2 miles, in one instance, within an experience of thirty years. This parallel extension southward, of the sands, coincident with that of the littoral deposits could not however be attributed to the same cause, but a parallel one, for the maiu course of the great Atlantic tidal wave from N. to S. towards the Thames, produced this effect on the sands, and the wind waves similarly affected the littoral deposit. The combined roadsteads formed by these sands, 20 miles in extent, were well-known to mariners. The great changes at Yarmouth were noticed, founded on a sea sand opposite the mouth of what was an estuary, when the Romans occupied these islands, with stations at Caistor, north, and Burgh, south. The sands, 5 miles in length, and 1000 acres in area, had been subject to great vicissitudes. The harbour at one period had two entrances, sometimes entirely blocked up, with different entrances at varying periods. The motion of the sands was progressively in a south direction; and at one time, before the formation of Lowestoft Ness, the outfall was as low down the coast as Corton, or 4 miles south of the existing outfall. This was at last confined by the present works, first commenced in the reign of Elizabeth, and the harbour was now one of the most important on the coast, with 10ft. at low water, employing five hundred vessels in the foreign trade, with prosperous shipbuilding yards, important marine institutions, and the town as a watering-place had in modern times been considerably extended. For 16 miles N.W. of Yarmouth, the peculiarity of the coast was a continuous belt of "marrams," or sand hills, forming a fluctuating defence to the various valleys and marsh land, situated between the outcrops of the tertiary downs. At Caistor these sand hills had been very much wasted by the sea, the hillocks represented entire in the Ordnance Survey being now cut in half. Winterton Ness, with "marrams" 50ft. to 60ft. high, next the sea, the single range northwards, towards Waxham, of about 70ft. in height, were described, as being nearly breached in some places. The same abrasion of the "marrams" occurred at Eccles. At Happisburgh, the tertiary cliffs had been wasted at the rate of 2¼ yards in depth per annum, during the last sixty years, and as they retreated, so were the sand "marrams," south eastward to Yarmouth, correspondingly impinged on. At Mundesley, the recession of the yellow sand cliffs had been so great, that the frontage was now protected by stone walls, which had suffered much from the sea; and northwards the mean loss, since the publication of the Ordnance Survey, was estimated at 4¾ yards per annum in depth. At Trimingham, the cliff, 200 feet high, formed a continuous avalanche of sand. At Sidestraud, the undercliffs and chines increased, and past Overstrand the same enormous slips were met with. Cromer had suffered much, standing on the north-east salient angle of the county; the portion of the town now remaining was dependent on sea-walls, forming a projecting point, as the cliffs rapidly wasted E. and W. of it. At East Runton and Beeston, where the chalk cropped out in more defined masses, mixed with sand, the diminution amounted to 2½ yards per annum over the last quarter of a century. At Sherringham there commenced a line of beaches travelling westward towards the Wash, forming Weybourn, Salthouse, Cley, and Blakeney beaches, which were the outworks to natural harbours at these places. Between Blakeney and Wells, and thence westward to Brancaster, a range of "marrams" formed an outer barrier at high water parallel to the high land, enclosing tidal estuaries of considerable area, the low water channels from which had formed harbours from the earliest historic periods.

The beaches on the east side of the Wash, from Hunstanton, or St. Edmund's Point, to Woolverton Creek, the boundary of the Norfolk Estuary Works, about 10 miles in length, formed under the high land of Snettisham, Sandringham, Woolverton, &c., with a well-defined motion southward, and their increase from a very early period, as defined by the admixture of shingle "fulls" with marsh, far inland, were glanced at. The shingle end of this district was shown by successive serial horns, at Woolverton Creek, above which, within the area of the Norfolk Estuary Works, all was pure warp, the shingle ceasing south of the Creek.

The object of this paper, like that of 1852 on the South Coast, was to describe the characteristics of a range of coast within certain limits, to trace the changes produced by constant natural causes, and the resultant influences on the various harbours; those of Harwich, Orford, Southwold, Yarmouth, Blakeney, Wells, and Brancaster, being mainly dependent on such natural barriers as those described; as also their improvement, or deterioration, which in some instances, as at Yarmouth, by judiciously constructed works, material improvement was effected, and as at Orford, where no assistance was rendered, great changes occurred, or as at Harwich, where from constant progressive change it was difficult to speculate on the ultimate result of the continued operation of natural agencies, unchecked by works of a conservative character.

ON THE ACTUAL STATE OF THE WORKS ON THE MONT CENIS TUNNEL, AND DESCRIPTION OF THE MACHINERY EMPLOYED.

By Mr. Thomas Sopwith, Jun.

This tunnel would form the completing link of the Victor Emmanuel Railway and be the means of putting France and Italy in direct railway communication. The railway on the French side was already opened to St. Michel, in Savoy, and on the Italian side to Susa, in Piedmont. When the whole line was completed, the mails and traffic with India might perhaps be advantageously transferred from Marseilles to some Italian port, as the Mediterranean sea transit would thus be materially shortened.

During the last twenty years many routes had been surveyed and recommended for crossing the great barrier of the Alps. Of these, that by the Mont Cenis was generally considered the most feasible; and it was only a question whether the mountain should be crossed by a series of inclines, or whether a tunnel should be made. In 1857, Messrs. Sommeiller, Grandis, and Grattoni brought before public notice a new system of boring by machinery, instead of by hand labour. A Government commission was appointed to examine and report upon it, and to see if it could be applied to the boring of the tunnel under Mont Cenis. Their report was favourable, and M. Sommeiller and his partners were shortly afterwards charged with the execution of the work.

The ends only were available for attack, it being impossible, as was known from the first, to sink shafts. It was feared that the ventilation would seriously retard, or altogether prevent, the completion of the tunnel; but this fear was uncalled for, as the artificial ventilation in collieries overcame greater natural difficulties, and the ventilating current passed through a longer distance than could possibly be required in this tunnel. M. Sommeiller also proposed to use compressed air for driving the machinery, and calculated that on its escape, a volume of fresh air would be supplied, adequate to the requirements of the workmen. The tunnel at the Modane, or French side, was of the following dimensions:—25ft. 3½in. wide at the base, 26ft. 2⅝in. wide at the broadest part, and 24ft. 7in. in height; the arch being a semicircle nearly. At Bardonnèche, the height was increased 11⅞in. The exact length between the ends was 7·5932 miles. The present ends would not be the permanent entrances, as it was intended that a curved gallery should leave the tunnel at the north side, 415 yards from the end, and at the south side 277 yards.

At Modane, the tunnel was built entirely with stone; at Bardonnèche, for the greater part, the side walls only were of stone, and the remainder of brick. The Bardonnèche end was 434ft. higher than that at Modane. For one-half the length of the tunnel, therefore, from Modane to the middle, the gradient would be 1 in 45½; the other side being driven with only sufficient fall, 1 in 2,000, to allow of the water escaping.

When the tunnel was complete, it was expected that there would be a constant current of air from the north to the south; the latter was not only the higher end, but the air was more rarified and exposed to the heat of the sun, whilst the entrance at Modane was under the shade of the mountain.

The establishment consisted at each end of machinery for compressing the air, workshops for making and repairing machinery, offices, storehouses, residences for the engineers, and barracks for the workmen. At Modane, the entrance of the tunnel was 328ft. above the bottom of the valley, where the workshops were placed, with which there was a communication by means of an inclined plane, worked by a water balance.

Different systems of tunnelling by machinery had been tried in England; amongst others one by Captain Penrice, R.E., in which it was intended to drive a gallery about 4½ft. diameter, and by means of repeated blows from a heavy frame loaded with knives, to reduce the whole of the excavated materials to small chippings and dust. It seemed, however, to the author, that any system of tunnelling must be deficient, which did not make so cheap and readily applicable a power as gunpowder available; and that by the trituration of the rock to such small particles, as in Captain Penrice's system, a great amount of work was unnecessarily performed.

In M. Sommeiller's system, whilst machinery was employed for accelerating the progress usually made by hand labour, gunpowder was also available. He had succeeded in producing a compact machine, not weighing more than 6cwt., which could pierce a common borehole, about 1¼in. diameter, and 3ft. deep, into a rock in twenty minutes, where two miners would have required two hours. Further, he had arranged a moveable support capable of carrying eleven such machines, any one of which could be worked at almost any angle, and of allowing the free action of each, in a gallery 10ft. square. This support could be removed when it was necessary to explode the holes bored by the machines. The machine was of very ingenious construction. It consisted of two parts;—one, a cylinder for propelling the borer against the rock; the second, a rotary engine for working the valve of the striking cylinder, turning the borer on its axis at each successive stroke, and advancing, or retiring, the striking cylinder, as occasion required. It gave 250 blows per minute. The effective pressure on the piston in striking was 216lbs.; the length of the stroke was from 2in. to 7½in. Although simplified as much as possible, the nature of the work the machines performed was so severe, that they were liable to frequent derangement, and a large stock was kept on hand. The cost of each machine was about £80. The

compressed air was used at a pressure of five atmospheres above atmospheric pressure, and was conveyed to the fore-head of the advanced gallery by a pipe $7\frac{5}{8}$in. in diameter. The advanced gallery was the only place where the machines were used; the enlarging of the tunnel to the full size, walling, &c., were performed by manual labour.

The system of working was to bore eighty holes in the fore-head of the advanced gallery. The frame and machines were then withdrawn, and a set of men charged and fired the holes; afterwards replaced by another set to remove the *déblais*. The division of time amongst the different classes of labour was very variable. It might, however, be averaged as—

From 6 to 8 hours for the machinists,
„ $1\frac{1}{2}$ „ 2 „ for charging and firing, and
„ 3 „ 5 „ for removing the *déblais*.

Thus there were almost two complete shifts every twenty-four hours. An alignment was made about once in three months, from an observatory at each end. As yet no error had been detected.

Three or four large holes, each about 4in. diameter, were bored near the centre of the fore-head. These were not charged and exploded, their purpose being to weaken the surrounding rock. The remainder were charged, those adjoining the centre being first fired, and the result of these explosions was a cavity. The remaining holes then exploded from this cavity outwards.

The workmen were industrious, under circumstances which required more than ordinary perseverance. A premium on their wages was given for more than a certain advancement per day. At the time of the author's visit, one metre per day was the standard. For a progress of

$1\frac{1}{10}$ metre per day ... $1\frac{1}{10}$ day's wages was paid.
$1\frac{1}{5}$ „ „ ... $1\frac{1}{5}$ „ „
$1\frac{3}{10}$ „ „ ... $1\frac{3}{10}$ „ „
$1\frac{4}{10}$ „ „ ... $1\frac{1}{2}$ „ „

This scale was subject to adjustment every fortnight.

The *déblais* resulting from the explosion of the eighty holes was removed in small waggons. Its removal was well organised, and considering the circumstances, quickly effected. It would be much accelerated, if it was possible to construct an iron frame, strong enough to be placed close to the fore-head at the time of the explosion, and receive without injury the products of explosion, which could be removed *en masse*, or nearly so.

Two descriptions of machines for compressing air were in use—one on the hydraulic ram principle, the other resembling a pump. In the first, the water was admitted, with a pressure of $85\frac{1}{4}$ft., into a column or vessel, containing air, about 14ft. high and 2ft. in diameter. The water by its momentum rushed up the column, compressed the volume of air, and forced it through a valve into a reservoir. The pressure valve being closed, the exhaust valve was opened, and the water fell in the column, at the same time its place was taken by air, and the machine became ready for another stroke. This machine made $2\frac{1}{2}$ strokes per minute, and was capable of supplying about 20 cubic feet of air, compressed to five atmospheres, per minute. The other machine consisted of a horizontal pump and two vertical branches. The piston was surrounded by water, which rose and fell alternately in the two columns; when it rose, compressing the air, and forcing it through the outlet valve; and when it fell, creating a vacuum, which was filled by air at atmospheric pressure.

The tunnel, on the 30th June, 1863, had been driven (including the advanced gallery) at Modane 1092·25 metres, and at Bardonnèche 1450·00 metres. The advancement in June last, at Modane, was at the rate of 4·719ft. per day. At this rate of progress at both ends, the tunnel would be finished in 9 years $2\frac{1}{2}$ months from that time. It was not, however, too much to expect a progress of 2 metres per day at each end, seeing that machines had only been in use at Bardonnèche about two years and a half, and at Modane half a year. A great part of that time had been taken up in experiments, and the men were not thoroughly habituated, as yet, to the manipulation of the machines. The machines were also being much improved. With an average rate of 2 metres per day from June 30th, 1863, 6 years 7 months would be required for the completion of the tunnel, as compared with 26 years 3 months by hand labour, at 1·655ft. per day at each end, the average rate of progress previous to the introduction of the machinery. The machinery in use at Mont Cenis was made, for the greater part, at Seraing, near Liége. M. Sommeiller confidently expected an advancement of 3 metres per day at each end. If that were the average from June 30th, 1863, the work would be completed in 4 years $8\frac{1}{2}$ months from that time.

In the advanced gallery at Modane, the number of workmen employed during the twenty-four hours was as follows:—

88 machinists, in two sets of 44 each.
9 chargers, in one set.
30 labourers for removing the *déblais*, in one set.

127	
344 men were also engaged in enlarging and walling, giving a total employed underground of—	
471, and including blacksmiths, stonedressers, and other labourers at the surface, there were employed at the tunnel	700
Mechanics, brakesmen, &c., in the workshops, machinery, &c.	240
Occasional labourers	100
Or a total at Modane of..	1,140

At Bardonnèche the number was greater, 1,200 to 1,400 being generally employed, giving a total of 2,540 on the works.

The result of a rough comparison was to show that, in the present development of the Sommeiller system, an advancement three times quicker than by hand labour might be effected, but at about two and a-half times the cost; judging rather of places where it might be generally applied, than by the Mont Cenis only. The proportion of two and a-half to one increase of cost referred only to what was known as mining charges in the advanced gallery, *i.e.*, wages, tools, candles, and gunpowder. This proportion was notably diminished in the case of a railway tunnel, where enlarging, timbering, walling, laying of rails, &c., were charges common to both systems. In the case of a tunnel through rock, costing, when completed, £30 per yard, the two systems might compare as follows—an increased advancement in favour of machinery of 3 to 1, at an increased cost of 4 to 3.

The ventilation was good in the advanced gallery, the exhaust air from the machines affording an ample supply. During the time of exploding the holes, a jet of air was left open. Further back, where the men were employed in enlarging the tunnel, the ventilation was insufficient. The tunnel was therefore being divided with a horizontal brattice—the upper section being in communication with a chimney on the mountain side. The air was intended to pass along the under side of this division, and then return by the upper part, which had an area of 7 square metres.

The works were now performed at the charge of the Italian Government. On their completion the French Government was to pay £760,000 for that portion of the tunnel situated in its territory—one-half the entire length—together with a premium of £20,000 for each year, by which a term of 25 years, counting from January 1st, 1862, was reduced. This premium would be increased to £24,000 for each year, by which a term of 15 years was reduced, counting from the same time. In addition, the French Government would pay interest at 5 per cent. per annum on such portion of the tunnel as was finished. If, however, the Italian Government did not complete the work within twenty-five years from the time of making the agreement, or if they renounced the works before that time, the French Government was absolved from further payment. If the works were finished, as there was every reason to suppose they would be, in ten years from June 30th, 1863, the French Government would pay £1,287,000 for the construction of one half of the tunnel, or at the rate of £210 per metre.

INSTITUTION OF MECHANICAL ENGINEERS.

ON THE EFFECTS OF SURFACE CONDENSERS ON STEAM BOILERS.

BY MR. JAMES JACK, OF LIVERPOOL.

Some three or four years ago condensation of the exhaust steam from marine engines by surface contact was looked upon as an experiment, and few steamship owners could be induced to try this system, which was new to them: and notwithstanding the development and complete success of tubular surface condensers, both in merchant ships and in the navy, more than a quarter of a century ago, and the reduction thereby effected in the consumption of fuel, the objection was raised that surface condensation could not have the advantages alleged, or it would never have been discontinued. At the present time, however, it is no longer an experiment, but a reality; for not only have surface condensers been largely introduced with new engines, but in many cases injection condensers have been taken out of working vessels, and surface condensers put in their place. As the writer's firm has constructed and fixed a considerable number of surface condensers during the last three or four years, and as certain actions have been found to take place on the tubes and plates of the boilers with these surface condensers, of such a character that the full advantages of the use of distilled water could not with impunity be obtained, it is the purpose of the present paper to give the particulars of these effects. The effects produced upon boilers where surface condensers are used must have been noticed by many engineers, and the object of the paper is therefore to induce discussion upon the subject and elicit information which will enable the great advantages in the saving of fuel resulting from the employment of surface condensers to be realised. As the boilers where surface condensers are used are insidiously and rapidly acted on, the danger of delay and of accident from explosion is thereby greatly increased, rendering the question one of serious importance.

Surface condensation may be considered an old idea; for Savery adopted the principle in 1698 in what may be called the first steam engine, having applied cold water to the outside of the cylinder; and even Watt devoted much time to it, although he afterwards finally abandoned it, stating that the objection of the size and expense of the tubular condenser for large engines made him resolve to sacrifice part of the power to convenience, and to employ large pumps. It was about 1832 that surface condensation became practically carried out. Mr. Samuel Hall having seen its advantages, constructed a surface condenser consisting of a casing containing a number of small tubes; and succeeded in overcoming the difficulty of making a tight joint between the water and steam spaces, which should allow for the expansion and contraction of the tubes. These condensers were introduced into both naval and mercantile ships; but although attended with considerable advantages they ultimately fell into disuse. Several modifications have since been proposed with different arrangements and constructions of the tubes, with the water inside instead of outside the tubes, or with a combined jet and surface condensation. There was a difficulty at first in obtaining some effective packing for the ends of the tubes; but after the long experience of india-rubber for the purpose, it may now be pronounced a success, for out of many thousands of joints which the writer's firm have made, not a single case of leakage has occurred.

Surface condensation is a process by which both the sensible and the latent heat of the steam are conveyed away; and although the adoption of any new system is necessarily slow, the writer does not doubt but that surface condensation will ultimately entirely supersede the jet. There are evils, however, which require remedying before surface condensation can be universally adopted for steamships; not in the condenser itself, but in the effects produced on the boilers by distilled water or something contained in it resulting from surface condensa-

tion. The writer will accordingly refer first to the effects of surface condensation on the boilers, and secondly to the probable cause of this destructive action.

A number of marine boilers which have come under the writer's observation, and may for convenience be distinguished by the letter A, had been in use for longer or shorter periods, none less than six months, supplying steam to engines having injection condensers. Salt water had been used for feeding the boilers, and a considerable incrustation had consequently taken place. Without going to the trouble and expense of cleaning these boilers, they were sent to sea immediately after the surface condensers were fitted in. Everything went on satisfactorily, and on returning from the first voyage the boilers were examined. It was found that the greater portion of the incrustation had fallen off, and that the surfaces of the boilers, that is the inner surfaces, were in very good condition for transmitting heat, showing that the adoption of distilled water for feed had been advantageous. Boilers of this class have uniformly had the incrustation nearly all removed by the action arising from the use of the surface condensers during the first voyage, and in every case the surfaces of the boilers have been found in good condition and still remain so, some of them now for as long a term as four years. Indeed surface condensation has here been in every sense a decided success.

The appearance of the inside of the boilers however was not that of clean iron. The surface seemed to be impregnated with some greyish matter, or to be altered in its chemical nature. That this impregnation or alteration of the surface prevented and still prevents injurious action on the metal will be gathered from a description of another lot of marine boilers, distinguished by the letter B, which were in all cases new boilers, sometimes with new engines and surface condensers, in other instances with old engines and new surface condensers. In port, before starting, a number of these boilers were filled with fresh water, while another number were filled with salt water. An examination after the first voyage, during which only distilled water had been used for feeding the boilers, showed the following effects, which were increased in every subsequent voyage, until the practice was adopted of feeding with say from one-sixth to one-tenth of salt water. First, both above and below the water line the surfaces of the plates, tubes, and rivets were covered with a deposit resembling hydrated oxide of iron, which, when the water was evaporated, was in the state of a fine impalpable brownish-coloured powder. This deposit was thickest above the water line, sometimes averaging ⅜in. thick. When the boilers were emptied a thick slimy deposit adhered all over the inside, an analysis of which showed that it consisted of

Oxide of iron	77·50
Moisture	19·75
Grease	0·85
Sulphate of lime	0·80
Oxide of copper	0·60
Traces of alumina and chloride of sodium and magnesium...	—
Loss	0·50
	100·00

Secondly, underneath this deposit the plates and tubes were found to be eaten into, indented, or "pitted." The indentations varied in diameter from the smallest speck to ⅝in., and in depth from the merest impression to the entire thickness of the plates or tubes. And although they were formed all over the boilers, they were most frequently found and were most numerous just over the fireplaces, and in those parts immediately in connexion with the greatest heat. In some of these parts the surface was entirely covered with the indentations; while in other parts as much as a square foot of plate, although subjected to the greatest heat, was free from them. The plates and tubes in all cases have been of the best iron and by good makers, and the "pittings" occur in what looks like iron of good quality with a good fibre, no slag or cinder being perceptible. So destructive was this pitting in boilers using the same water over and over again, that in one instance the tubes of new boilers were actually eaten through at the end of two or three voyages, extending over only a few months altogether, and it became necessary to put in new tubes, and to use a portion of salt water for feed to keep up an incrustation, so that the boilers should not be acted upon. If the iron of the boilers had been all of one make, it would naturally have been concluded that the pitting was due to the quality of the iron; but as the iron of different boilers had been obtained from different makers from time to time, the quality of the iron could not be blamed.

The presence in the boiler of a soft metal, such as copper from the condenser tubes, it was considered would induce a galvanic action such as might effect the iron in some way. But the analysis which was made of the deposit scraped from the boiler shows that there was scarcely a trace of any foreign metal there. Indeed it might have been concluded that a soft metal could not be present, for the tubes of the condenser and the copper pipes were all in a perfect condition. Even at the joints, made tight by india-rubber hardened by vulcanising, there was scarcely a speck of corrosion.

A search was then made to ascertain whether the gluey deposit was present that arises from the decomposition of the tallow and oil used for lubrication; as the writer had frequently heard that such a deposit took place in boilers where Hall's surface condensers were used. For the purpose of ascertaining this the mud cocks of a vessel were not opened for some time before arriving in port; and the fires were then put out on arrival and the mud discharged, when the only substance found was the watery brownish deposit before referred to. The deposit remaining in the bottom of the boiler was carefully examined, but here again there was only the same deposit. As it was believed that the lubricating material carried into the boilers with the feed might by continued subjection to heat form an acid capable of producing the effects observed, the kind of lubricating material employed was noticed, in order to ascertain whether animal or vegetable oils acted most injuriously; but it was found that the action went on as much with the one oil as with the other. In case, however, a fat acid, formed as already mentioned, might be the cause, pieces of chalk were put into the boilers, and from time to time fresh pieces were added; carbonate of soda was also mixed with the feed water in regular doses: but all to no purpose, the action went on getting worse and worse.

No other alternative was therefore left, nor is there at present any other as far as the writer has been able to learn, but to feed the boilers with a portion of salt water sufficient to keep a thin incrustation over the surface of the iron. It was suggested that the deposit was nothing else than rust or oxide of iron, and that it was formed by the chlorine present in the small proportion of salt water, which would combine with the iron to form chloride of iron; and this being readily decomposed by oxygen, oxide of iron would result. The difficulty here, however, was to know whence the oxygen was obtained; for the quantity of air entering with the feed water must have been very small indeed. It was also suggested that hydrochloric acid might be present from the small quantity of sea water that may have found its way into the boilers; but then the difficulty was to know where a quantity of the acid was to come from sufficient to act over such an extended surface, and so rapidly as the results showed.

It was found, however, by Mr. Rollo, one of the writer's partners, that in a pair of boilers at a sugar refinery there was the same brownish deposit adhering all over the boilers, and those parts subjected to the greatest heat were "pitted" in precisely the same manner as the second lot of marine boilers previously designated by the letter B. Exactly the same effects were being produced. These boilers were supplied with the same water over and over again, a small quantity of fresh water being added from time to time to make up for the loss. As the steam was passed only through iron pipes for melting the sugar, the damage to the boilers could not result either from the steam coming in contact with a soft metal, or from any lubricating material. The boilers were of the Cornish construction with one flue, and were worked at about the same pressure as the marine boilers B already referred to, say 20lbs. per square inch pressure. A pair of boilers of exactly the same construction, placed alongside the first pair and working at about the same pressure, but fed with water which had not been distilled, were then examined to learn what state they were in. But although put in about the same time as the two first examined, these boilers were found in good condition and likely to last for years, as there was not a sign of corrosion or "pitting;" whereas the two boilers working with distilled water had to be repaired.

The practical knowledge thus acquired necessarily led to the conclusion that the distilled water itself was the cause of the corrosion, instead of any galvanic action or any fatty acid. In reference to the question whether distilled water has any particular action on metals, the chemist Berthier found that nodular protuberances deposited on iron pipes containing distilled water consisted of 21 per cent. of protoxide of iron, 58 per cent. of peroxide of iron, 5 per cent. of carbonic acid, 14½ per cent. of water, and 1½ per cent. of silica. The iron pipes contained also a pulverulent substance, which could be produced at pleasure with distilled water to which a trace of carbonate of soda and common salt had been added, but not with an addition of caustic alkali. Distilled water is known to act powerfully on lead, and this action is attributed by Dr. Clark to the remarkable property that distilled water has, as compared with ordinary water, of dissolving free carbonic acid.

The writer does not presume to state confidently that distilled water is really itself the active destroyer of iron boilers; but, from the observations that have now been referred to and the information he has been enabled to obtain, he thinks there is sufficient evidence that distilled water is, if not the sole cause, at least an active agent in producing the corrosive effects that have been described. If this suggestion should lead to the remedy of the evils that have been experienced where distilled water alone has been used, another difficulty will have been overcome towards the complete introduction of surface condensers.

ROYAL INSTITUTION OF GREAT BRITAIN.

ON THE GLACIAL EPOCH.

By Edward Frankland, Esq., F.R.S.

Amongst the circumstances that have profoundly influenced the present physical condition of our earth, the action of ancient glaciers upon a scale of almost inconceivable magnitude has been gradually but irresistibly forcing itself upon the notice of philosophers since their attention was first called to it by Venetz and Esmark. There are few elevated regions in any quarter of the globe which do not exhibit indubitable evidence of the characteristic grinding and polishing action of ice-masses, although at present, perhaps, they are scarcely streaked by the snows of winter. In our own country the researches of Buckland, and especially of Ramsay, have clearly shown that the Highlands of Scotland, the mountains of Wales and Cumberland, and the limestone crags of Yorkshire, abound in these *roches moutonnés*, which leave no doubt that the valleys of those mountain ranges were once filled with glaciers of dimensions unsurpassed, if even equalled, by those which at the present day stream down the sides of their gigantic Swiss rivals. Nor was this perpetual ice of a former age confined to localities where no such phenomenon is now seen, but numerous observations have established that the glaciers of the present age, existing in Switzerland, Norway, and elsewhere, are but the nearly dried-up streamlets of ancient ice rivers of enormous size. These glaciers have eroded the Alpine valleys, of which they once held possession, have carved out the lochs and kyles of Scotland, as well as the grander fjords of Norway, and have contributed in a most essential manner to the present aspect of our mountain scenery. Ramsay and Tyndall have recently called attention to this action of ancient glaciers, and have contended with considerable plausibility, the former that the lake basins, the latter that the valleys of the Alps, have been thus, in great part, scooped out. In no part of the world, perhaps, can the phenomena of the glacial epoch be more advanta-

geously studied than in Norway, where the ice-scarred coasts and fjords are still fully exposed to the eye of the observer, side by side with the ocean, which furnished the crystalline material that formerly covered them. Two thousand miles of coast, from Christiania to the North Cape, afford almost uninterrupted evidence of the vast ice operations which, during the epoch in question, moulded nearly every feature of this remarkable country. Starting from Christiania, the the traveller caunot fail to remark the peculiar appearance of the gneiss and granite rocks composing the coast, as well as the innumerable islands which, forming a great natural breakwater, protect the shore from the heavy seas rolling in from the Atlantic. These rocks, here rarely rising to the height of 800 or 900ft., present nothing of that sharp rugged outline which generally characterizes such formations. On the contrary, they are smoothed eveu to the summits, all their angles worn off, aud every trace of boldness and asperity effaced. To the casual aud uninstructed observer the actiou of the sea suggests itself as a sufficient cause of these appearances; but it does not require much scrutiny to be convinced that the ocean waves have had little to do with this smoothing and polishing of the coast, since it is the surfaces sloping towards the land that are most acted upon, while in some places, where the rock descends precipitously towards the sea, and is subject to the dash of the waves, it has been protected from the abrading action, and presents merely a weathered surface.

Rounding the promontory of the Naze and proceeding northward, the coast presents, with slight exceptions, the same general features until the Arctic circle is approached, when the character of the sceuery rather suddeuly changes. The rocky hills acquire the dignity of mountains, and tower up in rugged, sharp, aud fantastic peaks, contrasting strongly with the rounded summits of the lower latitudes. But these arctic peaks owe their immunity from the abrading action of ice solely to their height; arouud their bases, and even high up their sides, the slow surges of the moving glacial sea have made their unmistakable marks, grinding, and even undercutting them into most extraordinary forms, as fine instances of which may be mentioned the Seven Sisters, and Torghatten, with its singular tunnel, just south of the Arctic circle; the Horseman, standing on the circle; and the mountains of the Folden and Vestfjords, north of it; the latter having been justly described by the Rev. R. Everest, as resembling the jaws of an immense shark.*

To account for the adveut and subsequeut disappearance of such vast masses of ice, various hypotheses have been propounded. It has been suggested that the temperature of space is not uniform, and that our solar system, in performing its proper motion among the stars, sometimes passes through regions of comparatively low temperature: accordiug to this hypothesis, the glacial epoch occurred during the passage of our system through such a cold portion of space. Some have imagined that the heat emitted by the sun is subject to variation, and that the glacial epoch happened during what may be termed a cold solar period. Others, again, believe that a different distribution of land and water, would render the climate of certain localities colder than it is at present, and would thns sufficiently account for the phenomena of the glacial epoch. Finally, Professor Kämtz considers that at the time of the glacial period the mountains were much higher than at present—Mount Blanc 20,000ft. for instance—the secondary and tertiary formations having been since eroded from their summits.

The two last assumptious are attended with formidable geological difficulties, especially when it is considered that the phenomeua of the epoch in question extended over the entire surface of the globe; tbey have, therefore, never acquired more tban a very partial acceptance. With regard to the two first-named hypotheses, my colleague, Professor Tyndall, has recently shown that they are founded upon an entirely erroneous conception of the conditious necessary to the phenomena sought to be explained. The formation of glaciers is a true process of distillation, requiring heat as much as cold for its due performance. The produce of a still would be diminished, not increased, by an absolute reduction of temperature. A greater differentiation of temperature is what is required to stimulate the operation into greater activity. Professor Tyndall does not suggest any cause for such exalted differeutiation during the glacial epoch; but he proves conclusively that both hypotheses, besides being totally unsupported by cosmical facts, are not only incompeteut to constitute such a cause, bnt also assume a condition of things which would cut off the glaciers at their source, by diminishing the evaporation upon which their existence essentially depends.

The speaker divided the great natural glacial apparatus into three parts—viz., the evaporator, the condenser, and the receiver. The part performed by the ocean as the evaporator is too obvious to need description. The two remaining portions of the apparatus, however, are generally confounded with each other. The mountains are in reality the receivers, or *icebearers*, and are only in a subordinate sense condensers. The true condenser is the dry air of the upper region of the atmosphere, which permits of the free radiation into space of tbe heat from aqueous vapour.†

All the hypotheses hitherto propounded having therefore failed, in the light of recent research, to account for the conditions which brought about the glacial epoch, the speaker felt less reluctance in advancing a new theory, which had gradually elaborated itself out of the impressions he had received during a recent visit to Norway. Auy such theory must take cognizance of the following points iu the history of the glacial epoch. 1st, That its effects were felt over the entire globe. 2nd, That it occurred at a geologically recent period. 3rd, That it was preceded by a period of indefinite duration, in which glacial action was either altogether wanting, or was at least comparatively insignificant. 4th, That during its coutinuance atmospheric precipitation was much greater, and the height of the snow-line considerably less thau at preseut. 5th, That it was followed by a period extending to the present time, when glacial action became again insignificant.

All these coudities he believed to be the natural sequences of the gradual secular cooling of the surface of our globe. *The sole cause of the phenomena of the glacial epoch was a higher temperature of the ocean than that which obtains at present.*

He theu examined the grounds upon which this hypothesis is based. Numerous observatious of the augmentation of temperature, at increasing depths from the surface of the earth, no longer leave room for doubt that the vast mass of materials constitutiug the interior of our globe is at the present moment at a temperature far higher tban that of the surface. If this be so, the conclusiou is almost inevitable, that at earlier periods of the earth's history this high temperature must, at all events at depths comparatively little removed from the surface, have beeu still higher, and that consequently the temperature of the surface itself must iu former ages have been much more influenced by the iuternal heat than is the case at the present day. Tracing thus back the thermal history of our earth, it is conceivable tbat the waters of the ocean once existed as aqueous vapour in our atmosphere—a coudition which it is imagined obtains at the present day in Jupiter, Venus, and other planets, whose superior size or closer proximity to the sun may be supposed to have retarded the refrigeration of their surfaces. From the period, therefore, when the cooling of the earth's crust permitted the ocean to assume the liquid condition, its waters have gradually cooled from the boiling point down to the present temperature, whilst the laud has also undergone a similar process of refrigeration. *It was during the later stages of this cooling operation that the glacial epoch occurred.* For this assumption, however, it is uecessary to establish tbat the rate of cooliug of the land and of the ocean surfaces was unequal, otherwise the more rapid evaporation of the ocean due to iucreased temperature would be more or less neutralised by the impaired efficiency of tbe proportionately warm icebearers. The speaker tben proceeded to describe the results of his numerous experiments, which conclusively proved that, under the conditions contemplated, the land would cool more rapidly than the sea. This effect is brought about principally by two causes, viz., the great specific heat of water compared with granite and other rocks, aud the comparative facility with wbich radiaut heat escapes from granite through moist air. The amounts of heat associated with equal weights of water and granite are as 5 to 1 in favour of the former, or, if equal volumes be taken, the water requires to lose twice as much heat as the granite in order to cool through the same number of degrees: but it is in regard to the escape of radiant heat from their surfaces that the superior retention of warmth by the oceanic waters is most strongly marked. The readiness witb which radiant heat escapes from equal surfaces of water and granite at the same temperature through perfectly dry air is nearly equal; but so soon as aqueous vapour is interposed in the path of these rays, the conditions become wonderfully altered; the escape of heat from both is iuterrupted, but its radiatiou from the water is retarded in by far the grestest degree. Tbis extraordinary intranscaleucy of aqueous vapour to rays issuing from water has just been conclusively proved iu tbe physical laboratory of this Institution by researches made by Professor Tyudall, aud uot yet published. The differeuce between granite and water arising from this cause becomes vastly augmented when it is considered that the icebearing surfaces occupy an elevated position above the level of the sea, consequently the mautle of aqueons vapour which their radiant heat had to penetrate must have been much more attenuated than the comparatively dense shell lyiug between them and the surface of the ocean. Thus the obscure rays of heat streamed into space from the icebearing surfaces with comparatively little interruption, whilst the radiation from the sea was as effectually retarded as if the latter had been protected with a thick envelope of non-couductiug material.

Whether we take into consideration, therefore, the couductivity of water and granite, their specific heats, or, fiually, the respective facilities with which they can, under the cosmical conditions contemplated, throw off their heat into space, we find everywhere a state of things tending much more to the conservation of the heat of the water than to tbe retention of that of the land; and this of course applies also, *mutatis mutandis*, to the reteution of that heat which is received from solar radiatiou. The luminous heat-rays of the sun pass freely through aqueous vapour, and are absorbed by both grauitic and oceanic surfaces, but, once absorbed, these rays issue forth again as obscure heat of two different qualities, or rates of vibration. To use Tyndall's beautiful explanation of the phenomeua, the vibrations of the liquid water molecules are of such rapidity as cau be best taken up and absorbed by the same molecules in the vaporous condition. But granite is a very complex substance, and fewer of the heat oscillations of its atoms are in unison with those of aqueous vapour; hence the heat vibratious of granite disturb the molecules of aqueous vapour in their passage through the atmosphere in a less degree, and consequently the granitic rays are less absorbed.

Thus, whilst the ocean retained a temperature considerably higher than at present, the icebearers had undergoue a considerably greater refrigeration. The evaporation from the ocean would therefore, at the period contemplated, be greater than it is at present, whilst the capabilities of the icebearers, as such, would not be perceptibly less. Moreover, it is evident that, during the whole of the cooliug period, the ocean must have been receiving heat from its floor, and thus have acted as a carrier of warmth from the comparatively profouud portions of tbe earth's crust to th oceanic surface. It thus resembled a mass of water contaiued in au evaporating basin, placed over a very slow and gradually decliuing fire. Under such conditions its cooling was protracted through a vast period, allowing sufficient time, between a temperature inimical to animal life and the commencement of the glacial epoch, to permit of the development and decay of those forms of animal life which existed in the pre-glacial seas.

The rate of evaporatiou of water at different temperatures and under various circumstances was determined by Dalton, whose results are embodied in the fol-

* The speaker was greatly indebted to his friend, B. F. Duppa, Esq., for beautiful coloured drawings of these remarkable objects, taken from the sketches of Professor James D. Forbes and Mr. Mattieu Williams.

† This radiation from aqueous vapour was experimentally shown by causing a jet of dry steam to pass in front of, and at a distance of 2ft. from, a thermo-electric pile; the galvanometer connected with the latter promptly showed a large deflection for heat, proving that the pile was receiving radiant heat from the aqueous vapour. A jet of air heated in the same manner and projected in front of the pile produced no such effect.

lowing table. The evaporation took place in each case from a circular surface 6in. in diameter:—

Temp. F.	Evaporation per minute in Calm.	Evaporation per minute in Breeze.	Evaporation per minute in High Wind.
	Grains.	Grains.	Grains.
85°	4·92	6·49	8·04
75°	3·65	4·68	5·72
65°	2·62	3·37	4·12
55°	1·90	2·43	2·98
45°	1·36	1·75	2·13
35°	·95	1·22	1·49

We have no sufficient data to calculate the preseut mean temperature of the oceau, but in latitude 69° 49′ off the coast of Norway, at noon on a remarkably hot summer's day, Professor Forbes fouud the temperature to be 46·5° Fahr. The assumption of 40° Fahr. as the mean temperature off the coast of Norway, would therefore probably be in excess of the truth. Now taking the mean of Dalton's results obtained at 35° and 45°, and compariug it with the mean of his results at 65°, it will be seen that an increase of 20° in the temperature of the ocean off the coast of Norway would double the evaporation, from a given surface. Such au increased evaporation, accompanied as it necessarily must be by a corresponding precipitation, would suffice to supply the higher portions of the land with that gigantic ice-burthen which groaned down the mountain slopes during the glacial epoch.

But would not the increased oceanic temperature tend to augment the mean temperature of the atmosphere even at considerable elevatious, and thus raise the suow-line and reduce the area of perpetual snow? In answering this question, the speaker showed that the limit of perpetual snow does not depend so much upou the mean temperature of the atmosphere at that particular elevation, as upon the amouut of snow accumulating during the cold season. Under the the equator, the meau temperature of the snow-line is 35° Fahr.; in the Alps and Pyrenees, 25°; and in lat. 68°, in Norway, it is only 21°. Thus the mean temperature of the snow-line rises as we approach the equator, which means that the snow-line itself descends below its uormal height, owing principally to augmented oceanic evaporation, accompanied by increased atmospheric precipitation. The deluges of rain which fall within the tropics far surpass the rainfall iu the temperate and frigid zones, and doubtless the fall of snow upon intertropical mountaius is proportionately great. The importaut influence which the amouut of precipitatiou exercises upon the lower limit of perpetual snow is beautifully exemplified at the fine waterfall of Tysse Strenger, near the head of the Hardanger Fjord, and was first noticed by Mr. M. Williams. The spray from this fall, being frozen in wiuter, covers the valley for nearly half a mile with a stratum of suow aud ice, so thick as to defy the solar rays of summer to melt it; thus lowering the snow-line by more than 2,000ft. The speaker had also seeu in the Sör Fjord, under similar abuormal conditions, a mass of snow lying in the month of August last within 10ft. of the level of the sea, although the normal snow-line is there at least 4,500ft. above the sea-level. That the height of the snow-line is essentially dependeut upon the amount of precipitation, aud not upou mean temperature, is evident from a comparison of its height on the coast and in the interior of the Scandinavian peninsula, as given by Forbes iu the followiug table, compiled partly from his own observations and partly from those of Von Buch, Naumann, and others.

Latitude.	Height of Snow-line in feet.		
	Coast.	Interior.	Difference.
60°	5,500	4,450	1,050
62°	5,200	4,150	1,050
64°	4,200	3,650	550
66°	3,700	3,250	450
68°	3,450	3,000	450
70°	3,350	2,900	450

Thus the differeuce between the height of the snow-line near the coast, where, owing to the impact of the gulf-stream, the winter is mild but the atmospheric precipitation great, and in the interior, where the climate is severe but the air comparatively dry, amounts in some cases to as much as 1,050ft., or nearly one-fourth of the total height. Such is the depressing effect of greater precipitation as regards the limit of perpetual snow; nor must it be forgotten that copious precipitation is altogether incompatible with great summer-heat. The incessantly clouded sky cuts off the solar rays, and moderates the summer temperature. It is a trite observatiou, that a wet summer is always a cold one. The mean temperature of the land in contiguity with such extensive surfaces of suow could also uot fail to be considerably reduced; for although the actual amouut of heat in activity at the surface of the earth was greater during the glacial period than subsequently, yet the cold of winter became stored up in masses of falliug suow, which in melting absorbed the heat of the succeeding summer, and thus reduced both the mean and summer temperature of the laud, especially of such portions of it as were not situated greatly below the snow-line. The common notion, therefore, that the glacial epoch was a cold one, is correct, although heat, not cold, was the *cause* of that epoch. This apparent paradox, that heat should be the cause of cold, fiuds its parallel in the ice-making machines which were in operation at the last Great Exhibition. In those machines which produced from 2 to 12 tons of ice per ton of coal, the glacial produce was directly proportional to the amount of heat developed by the combustion of coal.

But it is evident that this lowering of the snow-line by increased oceanic temperature could ouly occur within certaiu limits; for although the mean temperature of the snow-line might rise from 21°, its present position in Norway, to 35°, its height under the equator, and perhaps even still higher, without any elevation of the suow-line itself; yet a further rise of mean temperature, which would result from a continued augmeutation of oceanic heat, could not fail to elevate the snow-liue itself, and eventually to chase the last portions of snow eveu from the loftiest mountain peaks. A process the inverse of this has gone on in nature, leadiug gradually to the glacial epoch, and eventually to the present meteorological condition of our globe. Whilst the ocean maintaiued a high temperature, the snow-line floated above the summits, possibly even of the most lofty mountains; but with the reduction of oceanic temperature it gradually descended, enveloping peak after peak, in a perennial mantle, until during the glacial epoch it attained its lowest depressiou, whence it again rose, owiug to diminished evaporation, to its preseut position.

The speaker considered that, inasmuch as recent researches had rendered all previous hypotheses regarding the glacial epoch absolutely untenable, the one for which he now contended could not be said to come into antagonism with auy other views. It also further commended itself by requiring the assumptiou of no natural convulsion or catastrophe, no vast or suddeu upheavals or depressions, aud no change iu the thermal relations of our earth to the suu or to space. On the contrary, it insisted that the glacial epoch was normally and gradually evolved from a thermal condition of the interior of our globe, which could scarcely be said to be any longer the subject of controversy.

In conclusion, this hypothesis suggests the probability that the other bodies belonging to our solar system have either already passed through a similar epoch or are destined still to encounter it. With the exception of the polar ice of Mars we have hitherto obtaiued no certain glimpse into the thermal or meteorological condition of the planets; neither is the physical state of their surfaces accessible to our best telescopes. It is otherwise, however, with the moon, whose distance is not too great to prevent the visibility of comparatively minute details. A careful observation of the lunar surface for more than a year with a silvered-glass reflector of 7iuches' aperture and of good defining power, had created in the speaker's mind an impression that our satellite had, like its primary, also passed through a glacial epoch, and that several at least of the *valleys, rills*, and *streaks* of the lunar surface were not improbably due to former glacial action. Notwithstandiug the excelleut definition of modern telescopes, it could uot be expected that other than the most gigantic of the characteristic details of a glacier bed would be rendered visible. Under favourable circumstances, the terminanal moraine of a glacier attains to euormous dimensions; and consequently, of all the marks of a glacial valley, this would be the one most likely to be first perceived. Two such termiual moraines, oue of them a double one, appeared to him to be traceable upon the moon's surface. The first was situated near the termiuation of that remarkable streak which commences near the base of Tycho, and passing under the south-eastern wall of Bullialdus, into the ring of which it appears to cut, is gradually lost after passing crater 216 (Lubinietzky). Exactly opposite the last crater, and extending nearly across the streak in question, are two ridges forming the arcs of circles, whose centres are not coincident and whose external curvature is towards the north. Beyond the second ridge a talus slopes gradually dowu northwards to the general level of the lunar surface, the whole presenting an appearance reminding the observer of the concentric moraines of the Rhone glacier. These ridges are visible for the whole period duriug which that portion of the moon's surface is illuminated, but it is only about the third day after the first quarter aud at the corresponding phase of the wauing moon (when the sun's rays, falling nearly horizontally, throw the details of this part of the surface into strong relief) that these appearances suggest the explanation now offered.

The other ridge, answering to a terminal moraine, occurs at the northern extremity of that magnificent valley which runs past the eastern edge of Rheita. This ridge is nearly semicircular, and is considerably elevated, both above the northern termination of the valley, and the general surface of the moon. It may be seen about four days after new and full moon, but the position of the observer, with regard to the lights and shadows, renders its appearance in the rays of the rising sum by far the most striking.

With regard to the probability of former glacial, or even aqueous ageucy on the surface of the moon, difficulties of an apparently very formidable character present themselves. There is not ouly now no evidence whatever of the presuce of water in any one of its three forms, at the lunar surface; but, on the contrary, all seleuiographic observations tend to prove its absence. Nevertheless, the idea of former aqueous ageucy in the moon is by no means uew. It was entertained by Gruithuiseu and others. But if water at oue time existed ou the surface of the moon, whither has it disappeared? If we assume, in accordance with the nebular hypothesis, that the portions of matter composing respectively the earth and the moou once possessed au equally elevated temperature, it almost uecessarily follows that the moon, owing to the comparative smallness of its

mass, would cool much more rapidly than the earth; for whilst the volume of the moon is only about $\frac{1}{49}$th, its surface is uearly $\frac{1}{13}$th, that of the earth.

This cooling of the mass of the moou must, according to all analogy, have been attended with contraction, which can scarcely be conceived as occurring without the development of a cavernous structure in the interior. Much of this cavernous structure would doubtless communicate by means of fissures with the surface, and thus there would be provided an internal receptable for the ocean, from the depths of which even the burning sun of the long lunar day would be totally unable to dislodge more than traces of aqueous vapour. A globe of wax was exhibited which had been cast under water; it was highly cellular, and the water had been forced iuto the hollow spaces, completely filling them. Assumiug the solid mass of the moon to contract on cooling at the same rate as granite, its refrigeration through only 180° Fahr. would create cellular space equal to nearly 14½ millions of cubic miles, which would be more than sufficient to engulf the whole of the lunar ocean, supposing it to bear the same proportiou to the mass of the moon as our own ocean bears to that of the earth.

If such be the present condition of the moou, we cau scarcely avoid the conclusiou that a liquid oceau can only exist upon the surface of a planet, so long as the latter retains a high internal intemperature. The moon then becomes to us a prophetic picture of the ultimate fate which awaits our earth, when, deprived of an external ocean and of all but an annual rotation upon its axis,* it shall revolve round the sun an arid and lifeless wilderness—one hemisphere exposed to the perpetual glare of a cloudless sun, the other shrouded in eternal uight.

CORRESPONDENCE.

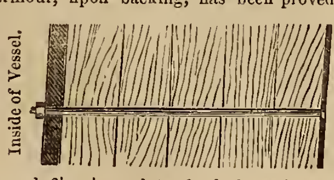
We cannot hold ourselves responsible for the opinions of our Correspondents.

PROPOSED IMPROVEMENTS IN VESSELS OF WAR, 1864.

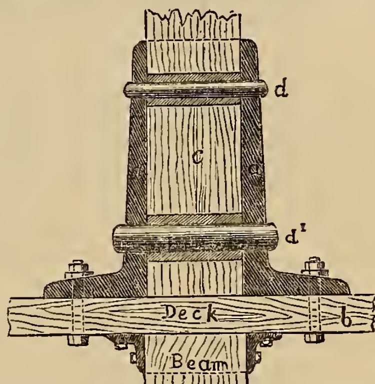
To the Editor of The Artizan.

Sir,—It is satisfactory, in reading of the accounts of the new war vessels now building for our navy from Mr. Reed's designs, to notice the progressive improvement shown in them both as regards armour protection, strength of construction, armament, speed, and stowage for fuel; though it is so difficult to attain all these important requisite qualities at the same time, and in a high degree iu the same vessel, that much still remains to be done.

It is to be feared that the great destructive power of steel, shot, and shell (now coming so much iuto use), has not beeu sufficiently considered and provided against, especially in the protection of the decks. Our ships should now be designed to be not only capable of resisting projectiles at present known and used, but also those much more powerful means of destruction which future improvements in the arts of war will bring against them. None of our present vessels are sufficiently protected by their present armour agaiust steel-shot. We shall be told that it is not possible to protect them strongly enough, so much are we limited by a vessel's weight carrying capacity, consistently with good sea-going qualities, and room for fuel. A war ship's size cannot, indeed, be increased beyond certain limits, without impairing its efficiency by rendering it comparatively unmanageable, and necessitating such a draught of water as to make it useless for coasting purposes. The weight of the armour for a large vessel would also be proportionately greater; also the engine power for sufficient speed, all these disadvantages increasing with the disadvantages of greater size. The medium size of ships for usefulness would seem to be not exceeding 250ft. length, by 41ft. beam (say about 2,200 tons), with a draught of water not to exceed (if possible) 17ft. Such a ship would be easily manageable both in turning and manœuvring, and, with a power of, say 500 horse-power, might attain an average speed of fourteen miles per hour, aud carry 400 tons fuel, sufficient for, say fourteen days' steaming, or a distance of nearly 5,000 miles. For mauy purposes, and to carry a lighter armament, smaller vessels might advantageously be employed; but to lighten them sufficiently, either speed, fuel, or armour, would have to be curtailed. To secure the advantages of streugth with lightness, we must carry the use of tough steel both in the hull and armour further than we have yet done—4½in. iron external armour, upou backing, has beeu proved useless to resist steel projectiles. Tough steel armour-plates placed internally, or at the back of a great thickness of teak beams well bolted together, would probably be found much superior, and arranged, as showu in the sketch. A 3½in. steel armour-plate inside a thickness of say 5½ft. of wood, would probably have as much resisting force (with little more weight) than an external 6in. iron-plate, backed, as is now done, with some 18in. of wood.



The space the thick backing would take out of the vessel (for some feet above and below the water line) is a drawback, but thick backing of some kind of material is necessary to deadcn the force and concussion of the blow. Its importance has been too much overlooked hitherto inour iron-clads; indeed, we seem to have gone back in this respect, for the *Warrior* armour is better backed than some later-built vessels. Unless we can contrive to turn the blow and cause projectiles to glance off the armour by strikiug at an angle, we shall probably find it most advantageous to place the armour-plates on the inside, for the force of the shot will be much deadened by the great thickness of wood before it reaches to damage the armour, whereas by the other plan dangerous splinters of wood would be driven about inside the ship Surely we are sufficiently advauced in working steel to be able to manufacture sufficiently thick and tough plates of it fit for armour. The decks, which hitherto have not been enough considered, might be covercd in a similar way, to protect the interior and machinery from shells. The strongest coustruction for a ship's bottom seems to be a double cellular construction of stcel plates, say ⅞in. thick, filled in with wood between (say 1ft.). The ship should be divided into four or five water-tight compartments, and should be so strongly built as to be fit for use as a ram, if needful. The masts might be made lowerable during fighting, which would be an advantage, as they would otherwise be liable to be shot away aud hamper the vessel by their fall. The annexcdsketch shows a simple coutrivance



for light-masted steamers, by which, turning in a socket, they are easily lowerable, and when up can easily be secured by bolts, stays, braces, and rigging. A is a strong iron casting (strougly fastened down to the deck), which rcceives the square eud of the mast *c* (which may be strengthened by being strapped with iron). Through this casting and mast, to correspoud, are holes for two strong steel pins, *dd'*, the lower one the strongest, say 7iu. diameter. If the upper one is driven out and the rigging lowered off (the top masts and yards being previously sent down), it is obvious that the mast may easily be lowered, turuing on the lower pin as an axis; of course the pins must be well fitted, and the lower one may work in a brass bush. Other substances besides wood have been suggested and might advautageously be tried, as backing, such as compressed cottou, earth, sand, or stone.

We must also try by the use of steel still further to lighten the machinery used; and perhaps power might advantageously be gained by using a rather higher pressure of steam than the 20lb. now commonly used in our navy. Ecouomy in consumption of fuel must also carefully be studied. We should also be glad to see the twin screw system fairly tried for large war vessels, as it offers greater powers of turning and manœuvriug and less draught of water with equal speed and economy of weight and fuel.

It is also suggested that to increase the weight of a ship's broadside, some of the guus might be made capable of being moved on tram or traversing ways from side to side across the vessel, which of course must therefore have more ports than guns on each side. The increase of power would be very valuable in au engagement, as it very seldom happens that a ship is engaged on both sides at once. For iustance, a vessel might on each side be pierced for six guns, but only carry four—two on each side being made moveable from side to side. Thus, though only carryiug eight guns in all, she would have a broadside power ou either side of six. Of course the port-holes must be well shielded and protected.

Such a ship as suggested (of 17ft. draught) would carry about 2,200 tous weight, viz.:—

Hull, say about	600	tons
Armour-plating, say about	650 to 750	„
Armament, crew, equipment, stores, &c., say	380	„
Machincry and water in boilers, say	190	„
Fuel	380	„
Total	2,200	„

Before further reconstructing our navy, it would be very desirable that the most eminent nautical and engineering men of the day should be consulted, to whom might be submitted for trial the many likely schemes of inventors on these subjects. This would greatly further the adoption of a sound system of naval construction for the future. The Admiralty plan hitherto seems to have beeu to build new armour-plated ships at great cost, and afterwards by experiment ou their targets to prove that they would easily be riddled by steel projectiles.

The writer has drawn up the following, which he submits as notes on some of the chief requirements for an efficient vessel of war at the present time. The numbering of these paragraphs is not, however, in any numerical order, as to their importance:—

1. That, for adaptability for coast or river use, its draught of water should be as small as possible, consistently with other following requirements.
2. That, to make it manageable, its size should be as small as possible, consistently with the following requirements, viz., Nos. 3, 4, 5, 6, and 7.
3. That it should possess good sea-going qualities in all weathers, the utmost means of quickness in turning and manœuvring and great speed under steam, for sail power should probably only be used as an auxiliary, and the masts, &c.,

* Mayer has recently proved that the action of the tides tends to arrest the motion of the earth upon its axis. And although it has been proved that since the time of Hipparchus the length of the terrestrial day has not increased by the 100th part of a second, yet this fact obviously leaves untouched the conclusion to which Mayer's reasoning leads.

should be lowerable, if necessary, out of harm's way during actual fighting, which also would be of advantage in using it as a ram.

4. It should be so constructed that it might be used, if necessary, as a ram without much danger to hull or machinery, though this, probably, would be only a secondary use.

5. That efficient vessels of war should have stowage room for at least two weeks' steaming. To secure this, economy in fuel and adaption of power is necessary.

6. It should have sufficient means of protection—armour plating (steel or iron, as may be proved to be best adapted for the purpose) and backing, which may be found best capable of resisting the most powerful steel projectiles or other destructive weapons. Also it should be capable of resisting the attack of rams or submarine machines, and the protection of its decks, machinery, and means of propulsion, and steering, should specially be considered.

7. It should possess every possible means of attack, whether by broadside or turret, and every facility for carrying and working in all weathers the most powerful guns likely to be used. (The men working the guns to be protected.)

8. Ample means of ventilation and light should, if possible, be afforded to the crew below, even though the ship be divided into water-tight compartments.

9. The ship's hull should be well protected from corrosion and fouling.

10. The crew should be as small as possible, consistently with perfect efficiency.

It yet remains to be proved whether Mr. Reed's or Captain Cole's new vessels possess these advantages, in many of which qualities our present ships are sadly deficient.

Yours, &c., W. S.

PRESSURE OF STEAM AT HIGH TEMPERATURES.

To the Editor of The Artizan.

Sir,—I offer my best thanks to Dr. Macquorn Rankine for the information contained in his letter, that the two tables of his at page 3 in the January number of The Artizan, are some of the results of a formula deduced by him as early as 1849 from M. Regnault's experiments. He is quite correct in stating that those results are practically identical with M. Regnault's experiments. I had observed this, and expressed myself accordingly, on the page aforesaid.

Jersey, Feb. 16, 1864. R. A. PEACOCK.

ANOTHER PLAN FOR A RAILWAY BETWEEN ENGLAND AND FRANCE.

To the Editor of The Artizan.

Sir,—I beg to forward you a plan for a railway between England and France. The same relates more especially to the piers or supports of the bridge. I propose that the same be made of iron, and hollow, and of the shape enclosed. Fig. 1 is a sectional view of a pier; A, plan; B, the railway when completed. This

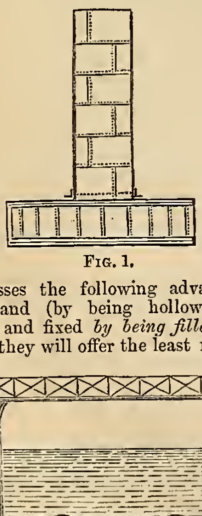
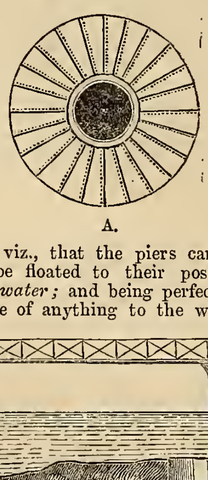
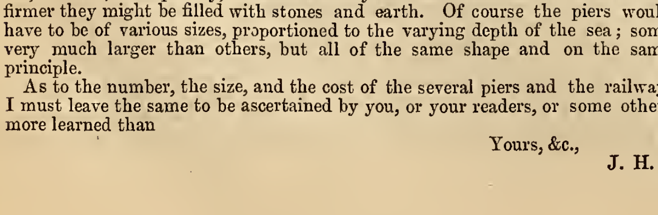


Fig. 1.



A.

plan possesses the following advantages, viz., that the piers can be made on land, and (by being hollow) can be floated to their positions, and then sunk and fixed *by being filled with water;* and being perfectly smooth and round they will offer the least resistance of anything to the waves of the



B.

sea, and will, consequently, remain stationary and immovable. To render them still firmer they might be filled with stones and earth. Of course the piers would have to be of various sizes, proportioned to the varying depth of the sea; some very much larger than others, but all of the same shape and on the same principle.

As to the number, the size, and the cost of the several piers and the railway, I must leave the same to be ascertained by you, or your readers, or some others more learned than

Yours, &c., J. H.

NOTICES TO CORRESPONDENTS.

R. E. D.—Messrs. Clinton and Owen (late Fowler and Co.), of Whitefriars'-street, Fleet-street, are the manufacturers of the pumps to which you refer.

J. S.—Consult the following works:—"Bourne's Treatise on the Steam Engine." Second edition. London: Longman and Co. 1861; and "Murray's Treatise on Shipbuilding and Steam Ships." Edinburgh: A. and C. Black. 1861.

RECENT LEGAL DECISIONS
AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

Under this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

Edwards *v.* De Normandy.—This case, tried in the Vice-Chancellor's Court, involved various complicated questions of account in respect of the profits made under certain English and American patents for obtaining pure and wholesome fresh water by distillation from sea water. The process in question had been invented and patented by the first defendant. The plaintiff had purchased an interest in the patent, which was worked by a company styled "Normandy's Patent Marine Aërated Fresh Water Company (limited)," and had filed this bill for an account of his share of the profits made by the sale of these machines. The Vice-Chancellor held that the plaintiff was entitled to the relief sought by him against the company, but not as against the other defendants, whose position as far as regarded the plaintiff was altogether different.

Wynne and another *v.* Allsopp and others.—This case, tried in the Court of Common Pleas, was an action for infringing a patent for an improvement in the apparatus for brewing. The defendant denied that the invention patented was new. The plaintiffs, Messrs. Wynne, are assignees of a patent for an invention of a gentleman named Tooth, lately a brewer at Burton. Formerly beer was filled into the cleansing casks from the fermenting tuns by a pipe having tubes into the several casks. The process of fermentation going on, yeast and beer were forced out of the bunghole up a syphon, and fell into a reservoir, from which it drained back again by other pipes into the casks to partially make good the waste. This process was called refilling; but these latter pipes had a tendency to choke up with yeast, the waste beer was exposed to the air in the reservoir, and became deprived of its carbonic acid gas. The patent of Mr. Tooth secured, by an arrangement of pipes, that the waste beer thrown out by the yeast into the reservoir should by gravitation drain into the main pipe from the fermenting tuns, the supply from which could be cut off at pleasure, and thus by gravitation the waste beer returned by one pipe to the cask and the refilling process with waste beer went steadily on, the pipe being kept flushed and clear of obstruction by the filling process from the fermenting tuns. The beer was thus made fresher, clearer, and with less waste. This invention, it was alleged, the defendants, the great brewers at Burton, had pirated and infringed, and applied to 1,300 union casks in their brewery at Burton, which were all filled and refilled from one main pipe made on this principle. Mr. Tooth's patent was taken out in 1856. For the defendants, it was shown that the same invention had been applied and used at Messrs. Flowers' brewery, at Stratford-on-Avon, as early as 1853, and a model made to scale of the plant in that brewery was produced in court, and was proved, on examination, the same in principle as Mr. Tooth's patent. On these facts being proved, the plaintiffs elected to be nonsuited.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible,* to the Editor.

MISCELLANEOUS.

Newspaper Statistics.—There are now published in the United Kingdom 1,250 newspapers, distributed as follows:—England, 919; Wales, 37; Scotland, 140; Ireland, 140; British Isles, 14. Of these there are—46 daily papers published in England; one ditto Wales; nine ditto Scotland; 14 ditto Ireland; one ditto British Isles.

The Permanent Exhibition Building, Paris.—Bills have just been posted in Paris announcing the sale of the Palace of the Permanent Exhibition at Auteuil. The upset price is fixed at 2,250,000f. The affairs of the company are about to be wound up.

Chief Occupations of the People.—The recent census of England shows the following list of occupations:—Agricultural servants and farm servants (without including members of the farmer's family), 1,188,789; domestic servants, 1,106,974; engaged on the calico and cotton manufacture, 456,646 persons; on the woollen cloth manufacture, 130,034; on the iron manufacture, 125,771; on the satin and silk manufacture, 101,670; coal miners, 246,613; dressmakers and milliners, 287,101; laundry people, 167,607; shoemakers, 250,581; tailors, 136,390; carpenters and joiners, 177,969; blacksmiths, 108,165. There are 309,883 persons described generally as "labourers."

British Empire.—The annual official volume just issued of statistical tables relating to the British possessions beyond the four seas shows us territory exceeding 4,000,000 of square miles, and containing a population of about 145,000,000 souls. There is India, with its 933,722 square miles and 135,634,244 people; the North American colonies (not reckoning the immense Hudson Bay and Red River territories), with their 498,169 square miles and 3,305,872 people; the West Indies, with 88,511 square miles and 1,081,687 people; Australia and New Zealand, with 2,582,070 square miles and 1,333,338 people; and there is Ceylon, the Cape, Mauritius, and the rest. The public revenues of these vast possessions amounted in 1861 to £56,218,420, India furnishing £42,903,234, of this amount. The public revenue of Victoria exceeded £3,000,000, and that of Canada exceeded £2,000,000. The public debt of India is stated at £101,877,081; of the North American colonies, £16,058,724; of the West Indies, £1,695,911; of Victoria, £6,285,060; of New South Wales, £4,017,630; of the Cape, £565,005. The imports into these our possessions amounted in value in the year 1861 to £93,945,835, and their exports to £86,286,034, and those figures are exclusive of Hong Kong and of Gibraltar, from which no return of these particulars is given. From the United Kingdom there was sent to them in that year produce and manufactures of the value of £47,412,166 (again with the omission of two colonies as before, and of the Ionian Islands); to India, £21,679,032; to Australia, £13,467,370. The shipping frequenting these territories in the year, counting both entrances inwards and clearances outwards, amounted to 22,849,461 tons.

Steam Fire Engine in Dublin.—A new steam fire engine, made by Messrs. Shand, Mason, and Co., has been added to the fire brigade of Dublin. On a recent trial, in the presence of the Lord Lieutenant, steam of 50lb. pressure was obtained in ten minutes after lighting the fire. The engine started with ⅞in. jet, the water gauge showing a pressure of 40lb. The steam rose rapidly to 80lb., and a ⅞in. jet was then used. When the steam pressure had risen to 120lb., with a water pressure of 100lb., a hose with an inch jet was attached, and directed against the Campanile; and, although a high wind was blowing from the opposite quarter, the water rose in one continuous column until it struck the lower cupola. But for the high wind this jet would have reached a much greater height. After playing for some time this hose was detached, and the ⅞in. jet was again tried, which threw a column of water fully 20ft. over the cross on the top of the bell tower, or, in other words, to a height of 120ft.

An Ancient Yacht.—There is now in Deptford Dockyard a model, constructed in the year 1558, of the yacht built for Queen Elizabeth. The model is in excellent preservation, and recently came into the possession of Mr. Brown, of the dockyard, at the sale of the effects of a deceased naval officer.

Sale of the "Great Eastern" Steamship.—On the 17th ult. Messrs. Cunard, Wilson, and Co. offered for unreserved sale the steamship *Great Eastern*. The Liverpool Cotton Sales Room, in which the auction took place, was densely crowded. The first bid was £20,000. She was knocked down at £25,000 to the representative of the Great Eastern Steamship Company (limited). This Company has only recently been formed, with the object of again running the vessel. The £25,000, however, only represents a small portion of the cost of the ship to the new company, as they have already purchased bonds of the Great Ship Company amounting to £70,000, and the actual cost of the ship to the new concern (after receiving the dividends on the bonds purchased) will be about £80,000.

Preventing Incrustation of Steam Boilers.—Mr. John Travis, of Royston, Lancashire, proposes the use of Irish moss, or silicate, arseniate, or phosphate of soda, to prevent incrustation of steam-boilers. From 6lbs. to 8lbs. per week usually suffices for a 40 or 50 horse-power boiler.

Induration of Stone.—Mr. F. S. Barff, of Dublin, for preserving and hardening brick, stone, and other surfaces, and timber, proposes to use soluble silicate of soda, or of potash, by preference the silicate of potash with a mixture of sulphate of barytes and carbonate of lime. The mixture is laid on with a brush.

A Fall of Nineteen Arches at Brixton, belonging to the South London Railway, in course of construction to connect the London, Chatham, and Dover Railway with the Crystal Palace and London-bridge stations, recently took place. These arches had been finished only about ten days, and the shoring under them had been removed. The sudden change from frost to rain is blamed for the accident.

Iron in New South Wales.—A bed of clay-iron has recently been discovered in the Illawarra district, between Balli and Coal Cliff. It lies horizontally embedded between sandstone; and the regular Wollongong coal measures lie a few hundred feet below it. The bed of iron ore is about 20ft. or 35ft. in thickness.

Revenue and Expenditure.—The estimated gross revenue for the year ending March 31st, 1863, was £70,050,000; the actual receipt at the Exchequer was £70,603,561, showing a surplus of £553,561. For the same period the estimated expenditure was £70,040,000; the actual expenditure £69,302,008. This amount is exclusive of the expenditure for fortifications, which was provided for by the creation of annuities and not estimated in the budget.

Substitute for Gutta Percha.—At a meeting of the French Academy of Sciences, M. Serres gave an account of the *Valata*, a shrub which abounds in Guiana, and affords a juice which he asserts is superior, for many purposes, to gutta percha, but especially as an insulating material for enveloping telegraphic wires. The milk or juice is drinkable, and used by the natives with coffee. It coagulates quickly when exposed to the air, and almost immediately when precipitated by alcohol, which also dissolves the resin of the *Valata* juice. All the articles made with gutta percha can be made with the sap of the *Valata*, and it has no disagreeable smell. When worked up it becomes as supple as cloth, and more flexible than gutta-percha. M. Serres exhibited a number of articles manufactured of *Valata* milk. Up to the present time it seems, from M. Serres's account, not to have become an article of commercial export.

Patents.—It appears from some elaborate statistics compiled by Mr. G. Shane, of Birmingham, that the number of patents applied for in 1863 was 3,309, against 3,490 in 1862, 3,276 in 1861, 3,196 in 1860, 3,000 in 1859, and 3,009 in 1858. These figures display a curious regularity in the efforts of the inventive talent of the country. Of the patents applied for last year 34 referred to sewing machines; 59 to wearing apparel and fastenings for the same; 33 to dressing and finishing woollen cloth and other woollen fabrics; 108 to warping and weaving machinery; 225 to balling, cleaning, and preparing cotton and other fibres; 20 to brakes, drags, and retarding apparatus; 20 to axletrees and axleboxes; 30 to wheel carriages; 20 to rudders and steering apparatus; 32 to sheathing and preserving ships' bottoms; 75 to ship and boat building, ship's fastenings, bolts, and pins; 50 to power obtained from undefined and sundry elements and sources; 43 to furnaces and furnace feeders saving fuel and consuming smoke; 118 to railways, locomotive engines, and carriages; 47 to marine engines and propelling machinery; 82 to steam boilers and generators; 93 to steam engines; 29 to anti-friction, composition, and arrangements; 53 to shot and projectiles, shot and powder cases, and fireworks; 43 to ordnance and gun carriages; 82 to firearms; 28 to locks, latches, and fastenings for doors; 31 to nails, bolts, screws, nuts, and rivets for machinery; 21 to metallurgical operations; 46 to sawing, planing, turning, and boring metals and wood; 38 to punching, die-sinking, stamping, carving, and ornamenting metals; 24 for tinning, casting, and plating metals; 26 for reaping and mowing machines; 22 for thrashing, separating, winnowing, and dressing grain, &c.; 32 for distilling apparatus; 30 for pumps; 29 for pipes and tubes for water, steam, and gas, and joints for ditto; 45 for cocks, taps, and valves; 65 for lamps, lanterns, chandeliers, and candlesticks; 30 for the generation of gas; 39 for warming and ventilating buildings, ships, carriages, &c.; 32 for stoves, grates, fire-places, and kitchen ranges; 58 for tunnels, bridges, arches, portable, and other buildings; 23 for letterpress printing machinery, setting up and distributing type, &c.; 20 for barometers, pressure gauges, thermometers, and hygrometers; 53 for telegraphs and making signals, cables, &c.; 40 for working mines and raising minerals; 22 for reducing and smelting ores; 33 for iron manufactures; 25 for steel manufactures, &c.

NAVAL ENGINEERING.

The "Caledonia," 35 guns, screw iron-cased vessel, 4,125 tons, now fitting at Sheerness for commission, is fast approaching completion, and will be ready for the pennant in April next. The vessel has been supplied by Messrs. Maudslay, Son, and Field with a pair of horizontal double piston-rod engines, of 1,000 nominal horse-power. The diameter of the cylinder is 92in., its length of stroke 4ft. The steam is obtained from eight boilers, four forward and four aft, with 32 furnaces and two stoke-holes. The stoke-holes are well ventilated by Baker's new ventilating apparatus. The engines are fitted with a four-bladed screw, the diameter of which is 21ft. The present pitch is 22ft. 5in., but it can be varied from 20ft. to 25ft. In consequence of their being no means of hoisting the screw, provision has been made for disconnecting it from the engines when the vessel is under sail, by means of a disconnecting coupling, whereby the screw is allowed to revolve. The contractors having completed the fitting of the engines, steam was got up on the 10th ult., for a preliminary trial at moorings in the large basin in Sheerness dockyard, which gave the greatest satisfaction. The trial lasted five hours, during which the maximum number of revolutions of engines was 40, the pressure of steam being 18lb., and the vacuum 22½in. Higher steam could have been easily obtained at full-power, had not this been prohibited by the authorities during trials in the basin.

The "Duncan," 80, screw line-of-battle ship, made a final trial of speed at the measured mile on the 6th ult., when she attained a mean speed, with full boiler power, of 11 knots, and with half-boiler power 9·200 knots. The ship drew 23ft. 5in of water forward, and 25ft. 8in. aft. The wind was strong from the N.W., and there was a scarcity of steam during two of the runs, or the rate of speed would have been somewhat higher. The machinery worked perfectly. The *Duncan* having received from a steam tender supernumerary seamen for the fleet on the North-American station, continued her voyage to Halifax and the West Indies.

Ships in Commission.—A statement made up to the 1st of December last shows that at that date we had 157 seagoing ships in commission, all steamers—namely, 10 line-of-battle ships, 5 iron-cased ships, 44 frigates and corvettes, and 98 sloops, small vessels, and gunboats. To these are to be added 44 harbour guard ships, stationary ships, &c., 5 of them steamers; 18 surveying, troop, and store ships, all steamers; and 43 tenders, 35 of them steam; making the total fleet 262 in number. There are still to be added 11 guard-ships of the coastguard, all steamers; and 63 tenders and cruisers, 17 of them steamers; making the total fleet and coastguard, including cruisers, 336. This number is 9 more than on the 1st December, 1862, but of seagoing ships the increase is only 2; for though there was 1 more iron-cased ship, and 6 more sloops, small vessels, and gunboats, there were 3 fewer line-of-battle ships, and 2 fewer frigates or corvettes.

For a "Wholly" Ironclad Vessel, a model and plans have recently been submitted to the Lords Commissioners of the Admiralty by Lieut. R. H. Napier R.N., the greatest advantage being a lighter draught of water than any war vessel afloat in proportion of tonnage (14ft. draught to a tonnage of 2,180). The estimated speed of the vessel is from 12 to 18 knots, and she will be capable of carrying any description of gun that can be used afloat.

Coating of Ships with Glass.—By direction of the Admiralty experiments have been carried out at Woolwich dockyard to ascertain the practicability of coating the bottom of iron ships on a plan invented by Mr. Leatch, which consists in coating the iron surface with gutta-percha or other cement, and on this soft material to fasten sheets of glass about a quarter of an inch thick. The glass is previously bent to the shape of the ship, and pierced for the reception of the screw or bolts, the apertures being lined with a soft adhesive composition, which prevents the fastenings from coming into immediate contact with the glass.

The Navy Estimates for the Years 1864-65 have been issued. They show a net decrease of £303,422. The total sum required to be voted for the service of the year, including £314,230 for the army department, conveyance of troops, is £10,432,610. The last vote was £10,736,032. The decrease in the estimates takes place in the following items:—For wages to seamen and marines, £47,304 less is asked; for victuals and clothing to ditto, £112,867 less; and in the matter of naval stores, for the building, repair, and outfit of the fleet, &c., the sum for the storekeeper-general of the navy is reduced by £169,951, and that for the comptroller of the navy by £195,137; half-pay to officers is reduced by £21,551; civil pensions and allowances by £949; medicines and medical stores by £1,650; wages to artificers abroad, £752; and the scientific branch by £685. The total of these items of decrease is £550,846; but against this is to be put an increase in other particulars of £247,424 distributed thus:—Admiralty Office, £3,283; coastguard service, £1,023; her Majesty's establishment at home, £9,258; her Majesty's establishments abroad, £1,296; wages to artificers employed at her Majesty's establishments at home, £162,438; new works in the yard, &c, £16,000; miscellaneous services, £2,950; military pensions and allowances, £7,096; and army department, conveyance of troops, £44,080; leaving the net decrease, as we have stated, £303,422. A statement prefixed to the estimates shows that the net amount of expenditure for naval services for the year 1862-63, after deducting extra receipts and repayments paid to the Exchequer, was £11,532,565 13s. 8d., the net amount for 1863-64 was £10,462,322, and the estimated net amount for the forthcoming year is £10,169,022.

The French Submarine Boat "Plongeur" it is stated, does not draw more than 8ft. of water, her engine is of 80 horse-power, steam is replaced by compressed air, and her crew of twelve men are completely protected from all danger. The *Plongeur* is intended to be a formidable engine of destruction. Her spur is formed like a tube, and an incendiary shell may be placed in it. Should an enemy's fleet be at anchor the *Plongeur* will drive her spur into the nearest ship and then retreat, unrolling at the same time a metallic wire. When at a safe distance an electric spark will cause a great explosion, the enemy's ship being blown up.

The "Research."—The contractor's trial of Messrs. James Watt and Co.'s engine on board this new iron-cased ship, took place on the 22nd ult. The mean speed of six trials at the measured mile gave 10·356 knots, and 85 revolutions. The wind was easterly. With the helm hard astarboard 39 degrees, she made the half circle in 1 min. 54 secs., and the circle in 3 min. 51 secs.; with the helm hard aport 38 degrees, she made the half circle in 1 min. 52 secs., and the circle in 3 min. 50 secs.

Naval Appointments.—The following appointments have taken place since our last:—W. C. Morton, in the *Fisgard*, promoted to Engineer; J. Russell, Assist. Engineer to the *Ajax*; T. F. Simmons, Chief Engineer, to the *Fisgard*, for the *Gorgon*; J. Dearden, Engineer to the *Duncan*, for service in the *Nimble* tender; H. Leslie, Engineer, to the *Asia*, for the *Pheasant*; R. H. Dobney and J. H. Bradshaw, Assist.-Engineers to the *Duncan*, additional, for service in the *Nimble* tender; C. Bulford, J. Wilson, E. M'Leish, J. P. Williams, W. T. Searle, and E. C. Scorrer, Assist.-Engineers to the *Duncan*, as additional, for disposal; J. E. Bain, Assist.-Engineer to the *Asia*, for the *Echo*; J. Jones, Assist.-Engineer to the *Asia*, for the *Fancy*; F. W. Henderson, First-class Assist.-Engineer to the *Cornwallis*, for the tenders; E. W. Boulton, Assist.-Engineer to the *Duncan*; W. N.

Covey, Chief Engineer to the *Osborne*; G. Gow, Chief Engineer to the *Duke of Wellington*; C. Wright, Chief Engineer to the *Cumberland*, for the *Hero*; T. W. Sandy, Chief Engineer, promoted and appointed to the *Fisgard*, for the *Hecate*; N. Farrant, Engineer to the *Cumberland*, for the *Pigeon*; T. J. Warburton and J. Elder, Second-class Assist.-Engineers to the *Hecate*; T. Segon, Engineer to the *Princess Royal*; Robert Brown, Engineer, to the *Hector*; A. Mills, Acting Engineer, to the *Adventure*; T. H. Kitts, First-class Assistant Engineer, to the *Defence*; A. B. Gutteridge, Acting Second-class Assistant Engineer, to the *Hector*; J. Hunter, First-class Assist.-Engineer to the *Jackal*; E. Boulton, Chief Engineer, to the *Princess Royal*; A. Symes and R. T. Rundle, Assist. Engineers, to the *Princess Royal*; A. Moreton, W. Fraser, and J. Cleland, Assist. Engineers to the *Princess Royal*, for the *Penguin*; R. Madge, acting Chief Enginneer, to the *Asia*, as Supernumerary; J. Torkington, Assist. Engineer, to the *Hector*; J. Elder, Assist. Engineer to the *Euryalus*; W. Donnison, Chief Engineer, to the *Indus*, for the *Megæra*; N. F. Hockerston, Assist. Engineer, to the *Asia*; A. G. Smith, Assist. Engineer, to the *Dromedary*; W. Lawson, in the *Styx*, and G. Duncan, in the *Princess Charlotte*, promoted to acting first-class Assist. Engineers; R. B. Turner, in the *Prince Consort*, J. A. Shawyer, in the *Pylades*, A. H. Symes, in the *Princess Royal*, and E. Chambers, in the *Hogue*, promoted to first-class Assist. Engineers.

MILITARY ENGINEERING.

Testing Armour-plates at Portsmouth.—Some testing of armour-plates has taken place at Portsmouth since our last. The plates were each of 5½in. in thickness, 15ft. 6in. in length, and 3ft. 3in. in width. One from Messrs. John Brown and Co., of Sheffield, was for the iron frigate *Agincourt*, and the other was sent in by the Millwall Ironworks for the iron frigate *Northumberland*. Both were tested in the first place with cast iron shot from the 68-pounder gun in the ordinary way. Both passed through the ordeal satisfactory, although tried severely by clusters of shot impacts and edge blows. The maximum depth of the indents was 2in., and the minimum 1 1-16in. On Brown and Co.'s plate, in its upper right centre, four shots struck in a semicular line, that measured but 32in. through the greatest extent of the curve. Throughout this space there was only one small surface crack. On the left lower corner of this plate five shots struck impinging on each circumference. Two of them were only half on the plate's edge. The plate exhibited wonderful tenacity and solidity, without the slightest appearance of brittleness. The Millwall plate was also struck in several places on its right lower edge, but without penetration being effected, although a small semicircular piece, 24in. in length by 10in. in width, was broken out through half the plate's thickness. The laminæ were opened on the plate's edge in the vicinity of the places struck. The places were of undoubted excellence both in the quality of the metal and in their manufacture. Messrs. Brown's plate was then selected for firing against, with improved cast-iron spherical (crucible) shot from the Elswick 100-pounder smooth-bore gun (diameter of bore 9in. and weight 120cwt. 2qrs.), with a charge of 25lb. of powder. Three shots were fired. No. 1 struck the lower edge and touched a bolt. It produced an indent of 4in. at its greatest depth, with a diameter of 9½in., and with only a surface crack round the indent. No. 2 struck just over the lower edge, producing an indent of 10in. in diameter and a greatest depth of 3 8-10in., with a slight surface crack in the indent. Both these shots were destroyed in the ordinary manner of casting projectiles. No. 3 shot struck fairly on the plate, and part of it remained fastened in the plate's outer surface. It will be seen that the damage inflicted by these improved cast-iron shot was hardly commensurate with their increased weight and the extra 9lb. of powder charge as compared with the 68-pounder gun. The Millwall plate had next three steel shots sent against it from the same Elswick gun, with a similar charge of 25lb. of powder, the result being—No. 1 shot struck about 4in. below the upper edge of the plate, a distance away from any damaged part, and, breaking right through, buried itself and the broken parts of the plate in the ship's side 12in. beyond the plate's inner surface. No. 2 shot struck the plate in a central and undamaged part, went clear through and buried itself with the broken fragments in the side of the ship, the outer surface of the shot being 3in. below the plate's outer surface. No. 3, the last shot, also struck the plate in a central and undamaged part, and about 2ft. aside of the last shot. It cut its way in with 9½in. diameter, about one-third of the plate thickness, and then carried everything before it on the lower deck of the target ship. The shot in passing through the broken pieces of plate increased the diameter of the hole it made on entering the plate from 9½in. to 3ft. at the other end. It passed entirely through one side of the ship and struck against the opposite side. The shot entering the plate by a hole 9½in. in diameter passed into the ship by a hole 3ft. in diameter, tearing five planks away from the inside and covering both sides of the deck for some distance round with broken pieces of wood and iron. One piece of plate, measuring 17in. by 14in., was picked up on the ship's deck, 15ft. from the side of the ship where it had entered with the shot. The shot itself was found on the opposite side of the ship's deck, and was but very little changed in form.

STEAM SHIPPING.

Steam Shipbuilding on the Clyde.—The *Constance Decma*, a paddle, recently launched by Messrs. Scott and Co., Cartsdyke, has made a satisfactory trial trip. Her destination is understood to be the South American coast. Messrs. W. Denny and Brothers have launched the *Dumbarton*, a paddle of nearly 1,500 tons, built for Messrs. T. A. Gibbs and Co., of London, and intended for the Chinese coasting trade. She is now being fitted with engines of 300 horse-power by Messrs. Denny and Co. Messrs. M'Nab and Co. have launched the *Adèle*, a screw, intended for the French trade, and built for Messrs. Seligman and Co., of Glasgow. Messrs. Caird and Co., of Cartsdyke, have launched the *Roe*, a paddle, built for the Glasgow and Belfast mail service, and another addition to the fine fleet of Messrs. Burns, of Glasgow. The *Roe's* dimensions are—length, 234ft.; breadth, 25ft.; depth, 14ft.; burden, 730 tons. She is now receiving a pair of oscillating engines of 250 horse-power.

The "Yuef Tze Tne," screw steamer, underwent a trial trip on the 13th ult., at Port Glasgow. This steamer was built by Messrs. Blackwood and Gordon, her dimensions being, 185ft. in length; breadth, 26ft.; depth, 12ft.; with a gross tounage of 621 tons. Her engines are 100 horse-power, and she is intended for the China trade. The trial was perfectly satisfactory, the *Yuef Tze Tne*, though deeply laden, fully came up to the contract speed. At full speed the complete circle was made in 4min. 19sec.; and at half speed in 5min. 25sec.

LAUNCHES.

The Launch of the West India and Pacific Steam Navigation Company's Steamship "Granadian," from Messrs. Pile, Spence and Co's. dockyard at West Hartlepool, took place on the 8th ult. The *Granadian*, 1,800 tons measurement, is calculated to carry 3,000 tons of cargo, including her fuel, and is the first steamer the company have had launched since their formation. The dimensions are as follows:—Length over all, 285ft.; extreme breadth, 34½ft.; depth of hold, 27ft. She is one of the strongest ships afloat, stands in the highest class at Lloyd's, and is classed for 22 years in the Liverpool Classification Book. She is double-plated to a breadth of 8ft. all round her sides; she is doubled in her bilge to a breadth of 8ft., has three very large box keelsons all along the flat of her bottom, attached to the outside of plating; has three tiers of beams, extra strong and extra fastened; has an iron main deck from end to end; has a teak upper deck, will be brig rigged, and splendidly furnished. This steamer is fitted with three steam winches for working cargo, and a steam windlass for hoisting her anchors. Her engines are 250 horse-power, by Messrs. Thomas Richardson and Sons, of Hartlepool.

Launch of the "Enterprise."—The iron screw steam vessel *Enterprise* was successfully launched on the 8th ult. at Deptford. She draws only 11ft. 4½in. with engines and boilers on board and armour on her sides. As her rigging and equipment will immerse her less than 3ft. more, it is now certain that she will carry all her weights (of guns, men, stores, &c.), and still have buoyancy to spare. This is considered extremely satisfactory in so small a ship, in which so much has been attempted. Her strength is proved to be unusually great from the fact that she is reported officially not to have "broken" in the slightest degree during the launch. The greater number of ships of her size break from ½in. to ⅝in.

Launch of a New Steamer for the African Mail Company.—There was launched from the shipbuilding yard of Messrs. Randolph, Elder, and Co., Glasgow, on the 8th ult., a fine new steamship, the *Calabar*, for the African Mail Company, of the following dimensions and power:—Length between perpendiculars, 255ft.; breadth, 31ft.; depth, 21ft.; tounage, 1,200 tons, old measurement; full poop, 80ft. long, fitted elegantly for seventy first-class passengers; full forecastle, for crew, forward; and large roundhouse, amidships, for officers, &c. The engines are of 250 nominal horse-power, on Messrs. Randolph, Elder, and Co.'s double-cylinder principle for economising fuel. There are two cylinders 66in. diameter, and two 34in. diameter and 3ft. 6in. stroke, steam jacketted, and fitted with surface condensers. The boilers are tubular, and formed to carry a working pressure of 40lb. on the square inch. This ship is a sister ship to the *M'Gregor Laird*, built by the same firm for the same company two years ago, and is the first of an extensive addition to their fleet.

The Launch of the "Eastern Province," screw steamer, from Mr. Laing's yard, at Deptford, recently took place. This vessel is the first of a class of steamers building for the trade between this country, Algoa Bay and Port Natal. Her dimensions are:—Length, 200ft.; breadth, 29ft.; depth, 16ft. 6in., making an aggregate of about 750 tons register. Her engines are of 90 horse-power nominal.

TELEGRAPHIC ENGINEERING.

Russian Telegraphs.—The telegraphic line between Omsk and Irkutzk is now finished. The first despatches sent from the latter town on the 21st of December, at noon, were received at St. Petersburgh the same day at half-past eight in the evening, having traversed the enormous distance of 5,750 versts (820 German miles). A letter from Irkutzk takes twenty-four days to arrive at St. Petersburg.

The Electric and International Telegraph Company's report for the half-year ending the 31st December, 1863, has been issued. The revenue for the half-year amounts to £137,150, exceeding that of the corresponding period of 1862 by £20,076. The total expenditure for working charges and interest on debentures amounts to £86,582, leaving a surplus of net profit on the six months of £50,568. The directors recommend a dividend of £3 10*s*. per cent. for the half-year.

The Persian Gulf Telegraph.—The *Marian Moore*, arrived at Bombay on the 22nd of December last, with 175 miles of the Persian Gulf telegraph cable, and shortly left for Gwadel on the Mekran coast, in tow of Her Majesty's ship *Semiramis*. The *Kirkham*, with 185 miles of the cable, including six miles of heavy shore end, reached Bombay on the 13th January last, and goes to Gwadel, towed by Her Majesty's ship *Zenobia*. Sir Charles Bright has left for Kurrachee with Colonel Stewart in Her Majesty's ship *Coromandel*, and will meet the cable ships at their destinations, when the submersion will commence from the *Kirkham*, which will be towed, after landing the shore end, in a westerly direction towards Ras Jask. When the whole of her cable has been laid from the three iron tanks in which it is coiled the end will be passed on board the *Marian Moore*, and the paying out will be continued from her as far as Ghubeht Ghazireh, a sandy inlet near Cape Mussendom, and about 12 miles from Khasab, where the station is prepared. From this point the cable will be laid from the *Assaye* towards Bushire, and the *Tweed* will supply the remainder to the head of the Gulf.

RAILWAYS.

Capital Expended on Railways.—The capital expended in this country on railways to the present time has been upwards of £385,000,000 sterling, or nearly half the national debt. This amount has been devoted to the construction of 11,500 miles of railway in the British Islands, which are now open for traffic. The works executed in connexion with these undertaking have been of extraordinary magnitude. Navigable rivers, and even arms of the sea, have been crossed over; hills have been pierced by tunnels, and viaducts, embankments, and cuttings made in all directions. All this has been accomplished within the life-time of a single generation of men, who have not only executed the work, but provided the means out of their private resources, without any assistance whatever from the funds of the State. In a word, the railway system of England has been the spontaneous out-growth of the native industry, energy, and enterprise of its people.

Railway Bills.—The Board of Trade have reported to the House of Commons that the bills relating to railways in the United Kingdom ask authority for new companies to construct 2,264 miles, and existing companies 835 miles,—in all, 3,099 miles of new railroads. There are also 66 miles of deviation lines proposed.

The Opening of the First Railway in New Zealand took place on the 2nd December last. The Christchurch and Heathcote Railway is only a small portion of a much larger work, which when completed will greatly tend to open the resources of the country.

Water for Locomotives.—The following we extract from *Herapath's Journal*, and is from the pen of Mr. Herapath:—"I think the directors and engineers of the various railways should pay more attention than they do to the nature of the waters they use in the locomotives. Almost all spring waters hold, besides soluble and alkaline salts, those of the earths, carbonates of lime and magnesia, and the sulphates of lime and strontia, and occasionally the sulphate of baryta. As soon as the temperature of the water arrives at the boiling point, the earthy carbonates begin to precipitate and form a loose powder at the bottom, but upon a continuance of the boiling they aggregate into a stony matter and become fixed to the top surfaces of the fire-pipes, and it also adheres to the bottom; all the earthy carbonates fall thus in a very short time. The stony concretion is not very hard, if none but carbonates are present in it. The earthy sulphates do not precipitate until the water is evaporated down to about 450 times the weight of the sulphate of lime contained in the remaining water, when they begin to precipitate, and continue to increase in the deposit until the entire water is evaporated. The stony matter is now very much harder than when it consisted only of carbonates of lime, magnesia, and perhaps iron, and requires sharp blows with the hammer and chisel to detach it from the surfaces to which it has adhered. But this is not the only injury to the action of the locomotive; the stony crust which has formed a thick coating over the surfaces on which the fire ought to act prevents the heat from passing direct through the iron or copper surfaces to the water, which, if in contact, would keep the surfaces at a moderate temperature, say 240 deg. Fahr., but not being in contact the plates get overheated or endangered by burning; at the same time fuel is wasted from the heat not passing through the crust, and escapes up the chimney. If the springs were examined at first only those samples would be selected which would leave the smallest and softest deposit, and thus many of the evils pointed out would be avoided. To show how various are spring waters in this respect, I send you a table containing those tried for a line of ninety miles. It is drawn up on the supposition that one ton of water (224 gallons) is boiled, when the num-

ber of pounds and decimal parts of carbonate of lime in the first column would precipitate, and the second column shows the number of pounds of sulphate of lime which would be found in addition if the whole of the water had evaporated.

No.	lbs. of Car. Lime per 224 gals.	Sulphate of Lime ditto.	No.	lbs. of Car. Lime per 224 gals.	Sulphate of Lime ditto.
1	1·02	1·31	12	4·30	2·36
2	6·59	21·45	13	5·73	2·15
3	2·35	1·17	14	4·66	4·35
4	2·36	1·53	15	3·27	1·12
5	3·58	4·10	16	2·45	·40
6	4·81	17·61	17	3·27	·56
7	5·29	7·00	18	5·94	3·11
8	2·45	2·35	19	4·40	1·22
9	5·73	3·28	20	1·17	·37
10	3·89	·97	21	2·35	2·04
11	4·04	·56	22	1·12	·97

Steel Rails, &c.—At the half-yearly meeting of the London and North Western Company, the chairman stated that the steel rails which had been laid down in some of their stations for a couple of years were showing those results which they anticipated when recommended for adoption. They found the steel rails wearing actually as long as ten pairs of iron rails would. On parts of their line there were some of the original rails laid down, and if these original rails had been of the right weight to bear the heavier engines of modern times, no doubt a large portion of them would be still existing. The company had also put up works for the manufacture of steel at Crewe, at a cost of from £35,000 to £40,000.

The Madrid and Irun Railway is now nearly completed, the only interruption being between Olazagoitia and Beazain, a distance of 46 kilometres (or about 30 miles), constituting the most difficult passage across the Pyrenees. It comprises no less than 23 tunnels, forming an aggregate length of 10 kilometres and a half (six and a half miles). The Otzeourte tunnel, which passes under the crest of the Pyrenees at an altitude of 614 metres above the level of the sea, is 1,158 metres in length. The Oazurza tunnel, pierced much lower, has a length of 2,950 metres. It was commenced in August, 1858, by the opening of nine shafts, of an average depth of 125 metres, the two central ones being 239 metres each in depth. The passage was opened on the 10th ult., and the meeting of the two branches of the tunnel, which had been commenced at both extremities, was ascertained to be perfect both in height and in direction. On the 11th ult., the communication was officially opened by the administrator of the company. The present state of the works is highly satisfactory. All the tunnels are now finished, except here and there the arching; and the grand viaduct of Ormaiztegui, 33 metres in height, and passing over five arches of 60 metres span, will soon be completed. It is expected the whole railway will be opened by about August next.

The Mont Cenis Locomotive.—A series of experiments has lately been concluded on the steep inclines of the Cromford and High Peak Railway, the object of which has been to prove the practicability of working locomotive engines and trains on a proposed railway over the pass of the Mont Cenis. The experimental line is 800yds., and the inclined planes on it 330yds. in length, on gradients of 1 in 12 and 1 in 13, and curves of 2½ and 3½ chains radius. The adhesion required for ascending these steep gradients and for controlling the descent of the trains is obtained by the pressure of horizontal wheels on a centre rail, these wheels being attached to the engine, and worked by an additional pair of cylinders. The experimental engine took up these inclines loads of 24 and 30 tons, consisting of four laden waggons, at a speed of seven to eight miles per hour, which rate of travelling, taking into account the increased speed that would be attained on the easier gradients of the road, would be sufficient to secure the passage of the mountain, a distance of 48 miles in four hours, by trains carrying 100 passengers each. The centre rail, besides affording the means of ascending and of controlling the descent, serves as a guide for passing round sharp curves, and also insures the safety of the train, which could not get off the line, in consequence of the flanges of the horizontal wheels, which underlap the centre rail, whereby the train is securely held on the line. The breaks applied to the three rails have perfect command over the train, which is readily stopped on any part of the inclines, and started again from that position without difficulty by the combined power of the engines acting on the vertical and horizontal wheels. The result of these trials is considered to have established the practicability of working locomotive engines and trains over the steep gradients of the existing route of the Mont Cenis. It is proposed to lay the rails on a portion of the public road, protected where needful from avalanches and snow-drifts by a covered way. By this means railway communication may within two years be established between Italy and France, as well as the north and west of Europe, and continue until the opening of the Grand Tunnel of the Alps 11½ years hence, the time estimated by the Italian Minister of Public Works for its completion.

RAILWAY ACCIDENTS.

Accident on the Glasgow and Greenock Line.—On the forenoon of the 5th ult., an accident occurred on the Glasgow and Greenock Railway, by which one passenger was killed and three others injured. It appears that while the passenger train which left Glasgow at eleven o'clock was between Bishopton and Langbank, running at a speed of about 27 miles an hour, the tire or outside ring of a wheel of the last third-class carriage broke in two. The flooring of the carriage was torn up, and one half of the tire flew into the guard's brake, and the other half into the carriage. In the former little damage was done—the guard, however, narrowly escaped.

Railway Accident on the North Eastern.—The long incline of the Malton and Whitby branch of the North-Eastern Railway was the scene of an accident, between nine and ten o'clock, on the night of the 11th ult. The last passenger train from Malton, consisting of two third-class carriages, one second-class, and one first-class carriages, with the van, travelled safely as far as the bank top in Gotbland. Here the engine was detached, and the train, as is usual, was booked on to a brake van, to which a rope of wire is attached, and was pushed over the bank on to the incline in the usual way. The trains are lowered by a stationary engine at the top, and on this occasion all was considered to be in proper working order. When about 150 yards on the descent the rope suddenly broke, and the train was left to its career down nearly a mile of incline of which the gradient is 1 in 14. At the foot of the incline the line curves rapidly to the right, crossing the Elderbeck in the Beck Hole. Round this curve and over the bridge the train shot with great speed, and a few yards further left the rails and rolled over into the ditch. The first-class carriage was upset, causing the immediate death of two of the passengers.

Collision on the Great Eastern Railway.—On the morning of the 9th ult., shortly before ten o'clock, an accident occurred at the Stansted Station, about three miles from Bishop-Stortford. It seems that at the time those in charge of the general up-goods train were engaged in shunting two of the trucks at the station, when a heavy train of carriages conveying coal, also on the up-line, was seen approaching. Notwithstanding that the engine-driver and guards at once put on the break, a collision was inevitable, owing, perhaps, as much to the frozen state of the rails as the short distance which intervened. The buffers and iron-work of the hind break van were split into pieces, and that heavy van itself was forced on to the adjoining waggon, crushing that and the next two, and wrenching from the sleepers some portion of the rails. Fortunately, however, the guard was not in the break van at the time, the engine driver and stoker of the coal train were somewhat shaken.

Collision on the North-Eastern.—On the evening of the 13th ult. a collision occurred on the North-Eastern Railway. The train which leaves Newcastle at half-past seven o'clock for South Shields and Sunderland was standing at the Springwell Station, on the Sunderland line, taking in passengers, when a coal train, coming in the same direction, suddenly approached, and before steps could be taken to prevent a collision it ran violently into the passenger train. The carriages were much damaged, but none of them were thrown off the line. Many of the passengers were hurt, but none seriously.

Accident on the Great Eastern.—On the night of the 12th ult., about a quarter past seven, the express train which left London at 4.25 p.m., and Ipswich at 6.42 p.m., when between the Finningham and Mellis stations met with an accident. The train was proceeding at its usual speed when the tire of one of the wheels of the break-van, which was next the tender, broke, and the van was thrown off the line, as well as the carriage next to it, the last carriage, there being but two in the train, retaining its place on the metals. In this position the train ran for 900 yards, the carriage and van bounding over the sleepers and cutting up the line. The passengers were much alarmed, though fortunately nobody was hurt.

A Collision on the West Midland section of the Great Western Railway, near Kidderminster, occurred on the 20th ult. The evening express from London, which leaves Worcester at 9·33 p.m., and is due at Kidderminster at 10 o'clock, had passed Hartlebury station, about three miles from Kidderminster, when it ran into a goods train on the same line of rails. The engine of the passenger train crushed up several trucks of the goods train, and then becoming detached from the carriages, ran off the rails and turned over on the up line. There was no loss of life, though many of the passengers were severely shaken. The cause of the accident arose from a goods train from the Severn Valley line breaking down between Hartlebury and Kidderminster.

BOILER EXPLOSIONS.

Manchester Association for the Prevention of Steam-boiler Explosions.—The ninth annual meeting of members of this association has been held, and the report of the year, an abstract of which we subjoin, was submitted. The chairman said he did not believe that during the existence of the association any other similar association in the country had rendered greater benefit to the public. If the association had not been, as it was, established ten years ago, the Government, from the number of accidents that occurred, would have established a rigid investigation, and would, probably, have taken upon themselves to do what the association was doing. He had taken a deep interest in the association from its commencement, and he took the same interest now, and continued to hope that it was doing a great deal of good, not only in the preservation of life and property, but by placing in the hands of millowners and steam users a knowledge of those powers and principles which were necessary for carrying out the purposes of the association, and the economical use of steam. He hoped they would be able to maintain the principles upon which they commenced, and thus to prevent parliamentary or Government interference; for he was sure it would be exceedingly irksome for members of the association to have a Government Inspector entering their premises to look after their steam-boilers. Mr. Fletcher, their chief engineer, had been most industrious in the collection of returns as to the number of explosions which had taken place in the country, so far as they were reliable, during the last twelve months. He thought it would be interesting if they could have a similar list extending over the last twenty years, or at all events over ten years, since the association had been established, because it would not only show the number of lives lost and injuries sustained, but would show the number of cases of accident which might have been prevented by careful and searching inspection, such as the association professed to carry out. He anticipated and hoped that the time was not far distant when they should be able to give regular annual information with regard to the number of explosions, so as to lead to the prevention of accidents and the mitigation of injuries. He concluded by moving the adoption of the report, which was seconded and passed. The chairman expressed his desire to see a museum established, and to have a fund provided by the association, whereby it could carry out a series of experiments, which would not only prove the just construction of boilers, but show the best means of economising steam. He did not see any reason why, as the result of experiment, they should not be able to work 200lbs. on the square inch, and, by adopting a large principle of expansion, use half the quantity of fuel, or do double the quantity of work with the same quantity of fuel. The question was only one of means, which he hoped would be provided. The report stated that the number of members, Dec. 31, was 431; numbers of works, 552; number of boilers, 1,458; the gross total number of examinations of boilers, 5,263; and the receipts for subscriptions, special service fees, &c., £1,268 13*s.* 9*d.* The committee are most desirous that the service rendered by the association should be one of faithful and searching inspection, considering that to be the only true method of preventing the recurrence of boiler explosions; and thus they view with considerable satisfaction the increased number of internal and thorough examinations that have been made of the boilers enrolled under the association, the number of these examinations in 1862 exceeding that of any preceding year since the association commenced operations, while the number in 1863 surpassed that again. The defects discovered in boilers are mainly of two distinct classes, one relating to their construction and the other to their condition. With regard to explosions, the conclusions drawn from a close inspection of the simple facts of each of the 36 explosions in 1863, the circumstances of which were ascertained, is that the whole question with regard to those under consideration admits of a very clear solution, and that the occurrence of all the explosions, with the exceptions only of that of the locomotive boiler, may be attributed to one or the other of two causes—either to the defective construction of the boiler in the first instance, or to the defective treatment it had received in the second, that treatment in some cases extending over a term of years, till it reduced the boiler to an unsafe state, and in others producing immediate explosion by a reckless tampering with the safety-valve, neglecting the water supply, or by other careless mismanagement. It is important that this view should be clearly brought before steam users, since the subject has too frequently been enveloped in mystery, and where mystery begins the adoption of vigorous measures for prevention is sure to end. Since an extra charge has been made for the indications of engines, but few members have had diagrams taken, added to which, the working throughout the district has been so irregular, owing to the depressed state of trade, that no correct coal accounts could be obtained, so that a comparative table of the economic working of the engines under inspection cannot now be given. Direct acting horizontal engines continue to be laid down, and although in some cases their cylinders have been fitted with steam jackets, the general introduction of this system has been retarded by the difficulty met with in the execution of the work, which, however, the manufacturing engineers of this districts will, no doubt, shortly overcome. The economy to be derived from the use of steam-jackets, where high pressure, expansion, and vacuum all take place by turns in the same cylinder, has long since been too well attested by experience to need remark; so that it only remains for the skill of the manufacturing engineers of the district to afford steam users the benefit of the principle. A surface-condenser has been set to work during the past year, and found to give satisfaction, while several others of similar construction are being applied in the neighbourhood. The water in the case first referred to is very sedimentary, and previous to the introduction of the surface-condensers the boilers had been thickly coated with incrustation, which, however, is now prevented by the adoption of the new system. Superheating has made but little progress during the past year. In conclusion, it may be stated that the experience of the past year affords

additional evidence of the soundness of the system of periodical boiler inspection, which the association has both inaugurated and maintained, as well as its efficiency for the prevention of boiler explosions.

Explosion at Aberdare.—A boiler explosion occurred at the Aberaman Iron-works Aberdare, Glamorganshire, on the 17th ult. The works are the property of Mr. Crawshay Bailey, M.P., and there are three furnaces worked on the hot-blast principle. Everything was going on as usual, when suddenly in the afternoon a tremendous crash was heard, and in an instant the engine house, boiler shed, and the adjoining buildings were one mass of ruins. The two boilers were blown on the puddling furnaces shed, and the latter was crushed as if it was made of waste paper. The ends of each boiler were blown out, and showers of broken metal and stones were hurled in all directions. Seven men were killed and fifteen others were injured, some seriously, by the flying fragments.

GAS SUPPLY.

Metropolitan Gas Dividends.—By a Parliamentary return it appears that the metropolitan gas companies paid dividends in 1862 as follows:—The Chartered paid dividends at the rate of 9 and 10 per cent., including back dividends at 1 per cent. per annum for the half year to Christmas, 1856; the City of London, dividends at 9 and 4 per cent., with a balance of £658; the Commercial, £30,513 on a capital stock of £322,195 (less sums remaining outstanding); the Equitable paid dividends at the rate of 11, 14½, 14, and 10 per cent. (less sums remaining outstanding), with a balance of £396; the Great Central dividends at the rate of 6 and 8 per cent. (less sums remaining outstanding), with a balance of £18,445; the Imperial at the rate of 10 per cent., with a balance of £58,500; the Independent at the rate of 10 per cent., with one year's back dividend (£1,500) and a balance of £3,548; the London paid £36,827 on £548,843 (less sum remaining outstanding); the Phœnix paid 10 per cent., with £8,190 dividend arrears for 1856, with a balance of £930; the Ratcliffe dividend was £8 15s. per cent., without a balance; the South Metropolitan, 10 per cent., with a balance of £10,369; the Surrey Consumers', with a balance of £4,047; and the Western, 10 per cent., with £5,285 "towards back dividends of less than 10 per cent."

The Devizes Gasworks Company are about to enlarge their means of gas production by an outlay of £2,000. This expenditure has, it is said, become absolutely necessary to enable them to meet the increased demand.

The Windsor Gas Company are reducing the price of their gas to 5s. 6d. per 1,000 cubic feet, being a reduction of 6d. per 1,000.

The Worcester New Gas-light Company have declared a dividend of 10 per cent· per annum, free of income-tax, for the past half-year. The last report of the gas inspector to the Local Board of Health states that in five experiments he found the average illuminating power of the gas to be 13·42 or 1·42 above the contract quality, which is 12 candles' illuminating power.

The Newcastle-under-Lyne Gas Company promise to reduce the price of their gas 6d. per 1,000 feet at the end of a year from the time when they took the concern into their own hands.

The Collingham Gas Company, Newark, have declared a dividend of 6 per cent· The report stated that the consumption of gas has again increased considerably, and the works have been extended and improved without trenching on the reserved fund.

The Price of Gas in Gloucester has been reduced from 5s. to 4s. 6d. per 1,000 cubic feet.

The Brecon Gas Company have declared a dividend at the rate of 10 per cent. per annum, besides "deficiencies" of former dividends for 1856, 1857, and 1858.

The Chester United Gas Company have declared their usual dividend of 7 per cent. on the preference stock and new shares, and a dividend of 10 per cent. on the ordinary stock; also the arrears of dividend of 1860, amounting to 33s. 4d. per cent.

The York Gas Company have declared a dividend of 10 per cent. per annum for the last half-year.

The Thorne Gas Company are said to be "in a flourishing condition; and the committee are enabled to declare a handsome dividend for the past year, besides reducing the price of gas 10d. per 1,000 feet, and also keeping a very respectable reserve fund."

London Gas Meter Company.—A prospectus has been issued of this Company, with a capital of £100,000 (of which half is to be first subscribed) in shares of £10. The object is to take over the business of Messrs. Bischoff, Brown, and Co., at a valuation, one-third in cash and two-thirds in paid-up shares, which are not to receive dividend until 7 per cent. is distributed on the remainder.

The Tunbridge Gas Company have declared a dividend of 7½ per cent.

The Bromyard Gas Company one of the same amount.

The Crowle Gas and Coke Company one of 10 per cent.

The Malvern Link Gas Company have declared a dividend of 5 per. cent. per annum, free of income-tax, for the last half-year, and laid aside a balance for their reserve fund.

The Westerham Gas Company have reduced their price from 7s. 6d. to 6s. 8d., and declared a dividend of £1 per share, free of income-tax.

The Redhill Gas Company's directors have determined still further to reduce the price of their gas from 7s. to 6s., having earned a dividend of 6 per cent., free of income-tax, by their last reduction, besides carrying a considerable balance to their reserve fund.

Coke Ovens in Connection with Gas Making.—Mr. G. Stevens has taken out a patent for improvements in coke ovens in connection with retorts for generating coal gas, the object of which is to economise fuel by making gas at the same time that hard coke is manufactured. This is effected by building a coke oven below, and an oven or retort for generating coal gas above, and in heating the latter with the surplus heats from the coke oven. The coke oven, with the floor laid dry in brick on edge, upon a thin layer of rubble or coarse gravel, spread over the solid brick foundation, the sides being upright upon which the arch is turned. Holes or perforations are made in this arch to allow the surplus heats to pass from the coke oven below into flues built round the gas oven or retort above. A double or revealed arch is turned over the mouth of the coke oven, at the bottom of which an iron plate is laid to protect the brickwork and from the sill. The coke oven is curved at the back, as well as on each side near the front, and is slightly curved on the top, while the entrance is splayed, and the angles at the junctions of the sides, built in fire-stone, with skewbacks at the top to receive the minor arch turned over the mouth. The gas retort is built over the coke even with a flat tile bottom, upright sides, and arched top; or the arch may spring from the floor without sides. Flues connected with the perforations in the arched top of the coke oven are built on the sides and top of the gas oven, traversing backwards and forwards, and alternately passing to the front and back ends of the latter, and ultimately into the main chimney. The front end of the gas oven has an iron plate with a mouth-piece and door, and a socket attached to receive the pipes that convey away the gas in the ordinary manner; and sight-holes are made in front to give a view into the several flues. In order to assist the combustion of the unconsumed gases arising in the early stages of each charge of the coke oven, a flue is formed for the purpose of admitting atmospheric air in small quantities, through perforations, into the flues surrounding the oven or retort, and at the entrance of this air-flue, a ventilator is fixed to regulate the supply. All the brickwork and tiles exposed to the fire are of fire-clay, as well as the front brickwork under the mouth of the coke oven.

Gas Supply to Gosport, Alverstoke, and Rowner.—A bill for the incorporation of a company to supply the above places with gas, has been printed. Clause 32 limits the price of the gas supplied to 4s. 6d. per 1,000 cubic feet, including the supply and fixing of metres. Clause 37 provides that the gas shall be of such a quality as to produce from an argand burner, having 15 holes and a 7-inch chimney, and consuming 5 cubic feet of gas per hour, a light equal in intensity to that produced by 12 sperm candles of six in the pound, burning 120 grains per hour; and shall, as far as reasonably practicable, be free from sulphuretted hydrogen and other compounds deteriorating its purity.

Gas Explosion at Aldershott.—On the evening of the 19th ult., an explosion of gas took place at the officers' quarters of the Carbineers, situate in the South Cavalry Barracks at Aldershott. It appears that for some days men had been engaged in repairing the water-pipes close to the gas meter in D entrance to the officers' mess-house, and while doing so had damaged one of the gas gipes and caused a large escape of gas. This appears to have commenced as early as half-past four, and owing to some negligence to have continued till twenty minutes to six. At this time a report took place. It blew up the central staircase, and scattered the fragments to a distance of 100 yards. At the same time nearly every window in the block of buildings in which the mess-house was situated was broken. Fortunately, although many persons were in the immediate vicinity, only one was seriously injured.

WATER SUPPLY.

The Paris Water Supply.—The Municipal Council have decided that two more artesian wells shall be bored in Paris—one at the Buttes aux Cailles, in the 13th arrondissement, on the left bank of the Seine, and the other at La Chapelle, in the 18th. The boring of these wells is to be continued with the greatest activity, in order that the new public garden about to be opened at the Butte aux Cailles may be well supplied with water. The new water machines erected at the Quai d'Austerlitz raise 22,000 cubic metres of Seine water every 24 hours. The Municipal Council are unceasing in pressing forward the works for conveying the waters of the river Dhuis to Paris. Eight miles of the aqueduct and three of the pipes are completed. It is the greatest work of the kind that has ever been undertaken in Paris. The reservoir will contain 100,000 cubic yards of water from the river Dhuis in its upper part, at 520ft. above the level of the sea, and 30,000 cubic yards of water from the river Marne in its lower part. Another reservoir, two stories high, is being constructed for the service of the high quarters of Paris, near Belville. The upper story will receive 15,000 cubic yards of water from the river Dhuis, by means of a machine, at a height of 450 feet above the level of the sea. The lower story will receive 25,000 cubic yards of water from the river Marne.

DOCKS, HARBOURS, BRIDGES, &c.

Extension of Leith Docks.—A new wet dock is to be constructed on the east side of the harbour, of greater depth and much larger dimensions than any of the existing wet docks on the west side; nearly doubling the present wet-dock accommodation. From a paper descriptive of the scheme, read at the Royal Scottish Society of Arts, it was stated that about 36 acres of the east sands of Leith are to be inclosed. The dock, with entrance-basin and lock, will occupy about 13 acres, leaving about 23 acres for wharfage and other purposes. Contracts have been entered into for the construction of the dock, amounting altogether to about £224,500.

Clifton Suspension Bridge.—The report states that the progress of these works has been as satisfactory as was anticipated, and the engineers' report confirms the anticipations of the directors that at the August meeting the works will be approaching completion. Measures are in contemplation for erecting villa residences in the Leigh woods, which cannot fail to be of service to the undertaking. The capital of the company is £35,000 of which less than £1,000 remains unprovided, and the directors feel confident that the deficiency will shortly be made good. The engineers (Messrs. Hawkshaw and Barlow), report that notwithstanding the unusually stormy weather in the autumn of last year, two of the main chains on the eastern side of the bridge have been completed and the fixing of the third chain is being proceeded with. The anchorages on the western side of the bridge are all completed, the anchor plates are fixed and everything is ready for proceeding with the chains as soon as temporary staging can be shifted over to that side. The accounts show a total receipt of £19,780 to the 31st of December last, of which a balance of £3,426 is unexpended.

Proposed American Suspension Bridge.—John A. Roebling, the engineer of the Niagara Suspension Bridge, thus proposes to build a bridge between the cities of New York and Brooklyn:—"I propose to start in the vicinity of the park of the city of New York, at an elevation of about 80ft. above tide, thence ascending about 125ft. to the centre of the East River (leaving a clear elevation of 180ft.), thence descending towards the heights of Brooklyn, and landing within sight of the City Hall. The superstructure of this bridge would thus form an arch about two miles long, clearing the water of the East River in one sweep of 1,600ft. to 1,800ft. span, and extending over the houses of both cities in a series of smaller spans, whose length would be gradually diminished from the East River tower towards either approach, say from 1,200ft. to 1,600ft. No ground will be occupied in either city, except one lot at each approach or entrance, about 600ft. deep, and about 50ft. front. For balance of the work only so much ground will have to be permanently occupied as is wanted for the location of the masonry of the piers. My plan provides two floors similar to the Niagara Bridge, the upper floor for railway conveyance, the lower one for promiscuous travellers on foot, horseback, or carriage. The entrance of the upper or railway floors will be next to the City Halls of New York and Brooklyn, and may be kept independent of the entrance of the lower floor, which may be located nearer to the river. Staircases next to the river shore would also furnish facilities of access to the lower floor for pedestrians. There will be side walks on both floors, and these will become favourite resorts for those who want to take exercise in the open air. The great majority of passengers will, of course, take the cars on the upper floor. The materials of construction will be principally granite and iron, the latter placed so that it can be readily preserved by painting. The rigidity of the superstructure will be as great as that of a tubular bridge. Iron trusses of great depth connecting both floors, together with effective over-floor stays, and the great weight of the structure itself, and inherent rigidity of the cables will provide ample stiffness."

Malta Harbour and our Iron-clads.—Mr. J. C. D. Hay, in a letter to the *Times* under the above heading, states as follows:—Malta dock has 22ft. 6in., or thereabouts, over the sill. The *Royal Oak* draws 26ft. A ship of her size and tonnage requires the removal of nearly 30 tons to lighten her one inch. She would require to be lightened three feet and a half at least to enter Malta dock, which would necessitate the removal of about 1,200 tons of stores. This involves the removal of men, guns, coals, and a large proportion of her stores and provisions—work which occupies time, labour, expense, and destruction of property and efficiency. The *Resistance* would require the removal of about 300 tons to lighten her for admission to Malta dock. All the ships of the *Minotaur* class would require the removal of nearly 2,000 tons of stores, &c. All the ships of the *Warrior* and *Royal Oak* classes would require to be dealt with like the *Royal Oak*. All these ships would require to be lightened from one to three feet, to reduce their draught to 25ft. and enable them to approach the site of the proposed new dock in the Marsa.

MINES, METALLURGY, &c.

Pure Copper Paint.—A new pigment, calculated at the same time to increase the resources of the decorative painter, and to afford a ready means of preserving iron and other metals, has recently been introduced at Paris by M. L. Oudry, of the Auteuil Electro-Metallurgic Works. He first obtains an absolutely pure copper by throwing down the metal by the galvanic process; he then reduces the precipitate to an impalpable powder by stamping. This powder is then combined with a particular preparation of benzine, and used in the same way as ordinary paint; beautiful bronzed effects are produced upon it by means of dressing with acidified solutions and pure copper powder. The articles painted with the new material have all the appearance of electro-bronze, whilst its cost is less than one-sixth; it will last from eight to ten years. M. Oudry also proposes to substitute benzine oil for linseed and other oils, over which he states it possesses great advantages.

An Extensive Vein of Iron Ore, said to be worth, at least, half a million of money, has been discovered by Mr. Wright, on the estate of the Prince of Wales at Sandringham. It is computed that the vein averages about 4ft. or 5ft. in depth, and will yield at least 2,000 tons per acre. Mr. Wright has informed the Prince of Wales, through General Knollys, of his discovery, and is in correspondence with him to work it at a Royalty.

Quarries of Paris.—The following curious details regarding the stone quarries on the left bank of the Seine are extracted from the *Dictionnaire des Général des Sciences.* The quarries of Paris are underground, and comprise four principal strata of limestone, forming a total thickness of about 15 meters. First in order comes the *banc de roche*, which is stone of the best quality, hard and finely grained; it rests on a stratum of inferior quality called *moellon.* The second principal stratum below the former is the *banc vert*, consisting of argillaceous limestone, which is burnt in kilns and yields good hydraulic cement; it is sometimes intersected with harder qualities, which are used for flagging. The third in order is the *lambourde*, or moliolite of geologists; it is rather soft, and used in a rough bewn state; the thickness of this stratum varies between eight and ten meters. The last stratum is the Banc St. Jacques, a soft limestone, interspersed with shells, and used for common building purposes. The workmen employed are:—1. *hommes de bricole*, or unskilled labourers, earning from 2f. to 3f. a day; 2. the *hommes d'atelier*, who perform accessory work, such as constructing supports, &c., and earn 4f. a day; 3. the *troncheurs*, who cut vertical grooves, two meters in depth, into the stone, so as to insulate the masses, which are each about 19 meters in length; these men earn 4f. 50c.; 4. the *soucheveurs*, who, lying down, cut a horizontal groove into the stone, so as to separate it from its base. As they go on, they put supports under, which are afterwards removed, when, after a short time, the whole mass breaks down by its own weight. These men earn 5f. a day; 5. the *équarrisseurs*, who square the blocks, earn about the same; and 6. the *conducteur*, or foreman, who directs the works, earns 5f. 50c. The average yield per annum of the Left Bank is 1,500,000 cubic meters, the extraction of which costs about 20,000,000f., and is sold for about 30,000,000f. In 1825 these quarries only yielded 485,902 cubic meters, which produced, at the rate of that period, 1,863,608f. The catacombs of Paris are old quarries which have been abandoned.

Mineral Wealth of Italy.—From a return published by the *Giornale dell' Ingegnere ed Architetto*, it appears that the annual value of the mineral production of Italy is as follows, viz.:—Sulphur, £800,000; iron, £480,000; lead, £280,000; tin, £120,000; boric acid, £60,000; fossil fuel, and turf, £56,000; nickel, £12,000; gold, £12,000; manganese, £4,000; iron pyrites, £3,200; antimonium, £2,400; graphite, £1,200; quicksilver, £800. Total, £1,831,600. It will be seen, that the production of sulphur is one of the most important industries. The exportation of sulphur from the various parts of Sicily in 1861, was as follows, viz.:—From Girgenti, 81,443 tons; Licata, 50,706 tons; Catania, 7,488 tons; Palermo, 8,275; Terranova, 6,242 tons. Total, 154,154 tons.

APPLIED CHEMISTRY.

On the Purification of Oxalic Acid, by M. Maumené.—The process given by some authors for the purification of pure oxalic acid is inaccurate. It is recommended to purify by successive crystallisations, replacing the mother liquors by distilled water. The last crystals, it is said, will be the most pure. The contrary really happens. However little alkali the acid contains, the successive crystals become richer and richer in it, which is easily understood when the less solubility of the acid oxalates is considered. M. Maumené dissolved a kilogramme of the ordinary acid in three litres of hot distilled water. The filtered solution deposited an abundance of very white crystals. Sixty-three grammes of these were dissolved in a litre of water, to make a standard solution of the acid. The weather was very cold, and the next day the author found crystals deposited. On calcination, 3·74 grammes of the dried crystals gave a residue of 0·64 $KOCO_2$, corresponding to nearly 1-16th of their weight of quadroxalate of potash; 4·95 grammes of crystals obtained from the mother liquor of the latter yielded 0·047 $KOCO_2$, equal to 1-105th of the total weight, or 1 of KO to 88 of C_2O_3. It is thus evident that the first crystals are richest in alkali, and successive crystallisation from pure water does not affect the purification of the acid. M. Maumené next examined the yellow mother liquor from the first crystals. This, on spontaneous evaporation, yielded a crop of beautiful crystals. 5·81 grammes of these gave, on calcination, only 0·010 of sulphate of lime, mixed with a little iron, and the residue had no action on reddened litmus. By a crystallisation from distilled water the purification was almost complete. 2·156 of well dried crystals gave only 0·002 of a non-alkaline residue. The way to obtain pure oxalic acid, then, is to dissolve ordinary acid in sufficient water to give 10 or per 20 cent. of crystals, according to the impurity of the sample. The first crystals are rejected, and the mother liquor is evaporated to furnish a fresh crop, which, after two or three crystallisations, will be found quite free from alkaline oxalates.

The Blowpipe Reaction of Copper.—Dr. B. W. Gerland, in a paper which appeared in the *Chemical News*, stated that the practitioners will share with me in astonishment when shown that the behaviour of the copper bead in the deoxidising flame—under circumstances whose control can be acquired by practice—is different to that described in chemical literature, and relied upon by all chemists as one of the most characteristic reactions. After long exercise, I have so far succeeded in the management of the blowpipe flame produced by a gas jet, as to have it sufficiently under my control to use it for all purposes of qualitative and quantitative blowpipe analysis; but I have been unable to obtain the red opaque copper bead on the eye of a platinum wire in the deoxidising flame. The bead thus produced shows the characteristics of glass colourless and transparent, and remains so after cooling; but when again gently heated by holding it close to the flame, a beautiful rudy red diffuses itself through the glass without disturbing its transparency. This colour is not affected by cooling, but disappears by exposure to a stronger heat, and does not return with cooling. It can, however, be reproduced by a low heat, as in the first instance. The changes are best observed when the bend of the platinum wire is made rather wide, and not too much borax used, so that the bead becomes elongated. If a little copper is dissolved in the flux, the glass is rendered colourless in the deoxidising flame, and one end of the bead is brought near the flame. This half turns ruby-red, whilst the other half is left too cold to take the colour; but the first half, when left for a moment in the exterior flame, becomes colourless by over-heating, and at the same time the other end is heated sufficiently to redden in its turn. When a large quantity of borax is used for the experiment, it sometimes happens that, after treatment in the deoxidising flame, the ruby colour appears during the cooling of the bead. The reaction is extremely sensitive. If the borax contains so little copper that the oxidised bead scarcely shows a bluish tint, or shows it only when held in the yellow flame, it can in the described manner he coloured a decided ruby. I have even obtained the ruby colour when the only source of the copper was that which the flame volatilised from the copper burner, moistened with hydrochloric acid. The importance of the reaction is still more evident from the fact, that it is not concealed by the presence of other metals which colour the glass under the same circumstances, unless their quantity is so great as to make the bead opaque. If, for instance, the flux contain chromium, the presence of a small quantity of copper manifests itself in the change of the green when treated in the described manner. Such metals as lead, bismuth, &c., which, in the deoxidising flame, darken the glass by the separation of a metallic substance or of a lower oxide, do not interfere with this reaction; for if their quantity is not large enough to make the bead quite black, the rudy colour can easily be observed, particularly by the change produced in warming, whereas in the other case it will be found easy to separate the large proportion of the metal in flakes, thus leaving the glass lighter coloured. Molybdanium, when present in large proportion, requires attention from the following peculiarity of behaviour. If present in sufficient quantity, this metal colours the deoxidised borax smoky brown, leaving it transparent, but the colour changes into dark brown, and the glass becomes opaque when reheated. It is therefore advisable to volatilise the molybdanium by a longer exposure to the blowpipe flame. I have in this way been able to discover in its compounds minute traces of copper when all other means failed in detecting its presence. The appearance of the ruby colour in the colourless deoxidised bead seems to be conditioned by the first degree of softening of the glass, and disappears when it is molten. The reaction can be produced both with borax and phosphate of ammonia, but the latter has the advantage of making the test less sensitive; and the colouring and discolouring might easily escape notice, in consequence of the low melting-point of the flux. The ruby colour of the salt of phosphorus bead has been already observed by Berzelius, who describes it in the following words:—"Salt of phosphorus dissolves it (copper) with the same colour as borax. The glass, containing a small amount of copper, after treatment in the reduction-flame, becomes sometimes ruby red, and this takes place generally at the moment of congealment." Other authors make no mention of this. The introduction of metallic tin into the bead, which is recommended to facilitate the deoxidation of the oxide of copper in the flux for the production of red opaque glass, has no effect upon the reaction. The depth of the ruby colour depends upon the quantity of copper in solution. In conclusion, I have to mention that in all my experiments by which the ruby glass was obtained, metallic copper had separated from the flux, and was found alloyed with the platinum of the wire. In fact, by prolonged treatment in the deoxidising flame, the copper can be perfectly separated from the glass. The wire can be boiled with water and with sulphuric acid without parting with its copper, but when borax is again fluxed on the same in the exterior flame, this metal slowly dissolves itself. This way of cleaning the platinum is, however, very tedious, and it is preferable to add some saltpetre to the flux.

The Influence of Fluxes on the Composition of Manganiferous Cast Irons, by M. H. Caron.—In a recent note I showed by experiments, supported by analyses, that manganese served, in cast irons, to expel sulphur, and often silicium; I added, that sulphurous and silicious cast iron might be improved by cast irons charged with manganese, which would be the more valuable according to their richness in manganese. Consequently, it would be well to possess means of extracting from the ore the cast iron most charged with this purifying metal. There are two causes, all other things being equal, which singularly influence the amount of manganese contained in cast iron:—1st. The flux employed in the reduction of the ore. 2nd. The temperature at which this reduction is effected. I have ascertained the effects of these two causes by experiments, of which I will here give some description. The ore on which I operated was a carbonate of iron and manganese, having the following composition:—

Carbonate of iron	71·0
Carbonate of manganese	13·3
Carbonate of magnesia	11·2
Carbonate of lime	0·2
Silica (quartz)	4·3
	100·0

Several kilogrammes of this ore were finely pulverised and perfectly mixed together In each of the assays, of which I shall give you the results, I used the same quantity of this ore; the wood charcoal mixed with the ore was in each instance used in the same way: finally, all the crucibles were brasqued with a mixture of graphite and molasses, or coal-tar. The following table shows the kind and the quantity of flux used per cent. of ore, and the colour of the cast irons obtained, as well as their richness in silicium and manganese. In the experiments from Nos. 1 to 5, inclusive, the temperature employed for the reduction was always decidedly the same;—the temperature for No. 6 was as low as possible (high enough, however, to allow the cast iron to collect). In assay No. 7, on the contrary, the heat must have been great enough to melt several hundred grammes of soft steel:—

No.		Colour of the cast iron.	Manganese per cent.	Silicium per cent.
1. Carbonate of lime	10	White	7·93	0·05
2. Carbonate of lime	5	White	6·32	0·08
3. Fluoride of calcium	5		4·70	0·30
4. Silicious earth	5	Grey	3·81	0·55
5. Silicious earth	10	Very grey	2·25	0·76
6. Silicious earth	5	Grey	3·90	0·50 Low temp.
7. Silicious earth	5	Grey	2·10	0·75 High temp.

Assays Nos. 1, 2, 3, 4, and 5, show that, to obtain cast iron rich in manganese from a given ore, as much lime must be used as can be introduced without spoiling the fusibility of the slag. It will be found, on the contrary, that the proportion of manganese diminishes as the silicious flux increases, and what is remarkable, that, as the manganese disappears, silicium takes its place in the cast iron. The temperature used for the reduction also exercises a notable influence on the richness of the cast iron in manganese. Assays 6 and 7 show that the higher the temperature the less manganese, but the more silicium will be found in the cast iron. As in the preceding experiments, silicium and manganese seem mutually to exclude one another. It will not be uninteresting to observe the nature of the cast irons obtained. A sufficient quantity of lime produces white cast irons, while silicia produces grey. By simply changing the flux, we may then obtain it at will, either white or grey steel or iron, or cast iron. I will not further enlarge upon these results; they are such as can be perfectly appreciated by metallurgists. I speak now of cast irons obtained with iron ores containing oxide of manganese or mixtures with it. Lime has not exactly the same influence on non-manganiferous ores; but the question should be treated in a special manner, and I trust soon to be able so to treat it. The assays, the results of which I have laid before the academy, are only laboratory experiments, but still I hope they may prove of some service. Thus, ironmasters who mix ores rich in manganese with their ordinary ores (sulphuretted or silicated), for the purpose of ameliorating their products, may without fear gradually increase the usual quantity of flux without seriously diminishing the liquidity of their slag. If the flux thus modified becomes too refractory, the addition of sea salt or chloride of calcium soon gives them the desired amount of fusibility. In this case, fluor-spar or cryolite will produce the same effects; but as these bodies, especially the latter, always contain notable quantities of phosphoric acid, which is very destructive to cast iron, the greatest care must be taken in using them.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent, Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated January 25th, 1864.

202 J. Piddington—Paper
203 W. Ibotson—Bleaching materials for paper making
204 H. A. Bonneville—Apparatus for recovering ships
205 W. Tasker—Corn dressing and winnowing machines
206 W. D. Grimshaw—Atmospheric hammer
207 W. Tasker—Drays or carts
208 S. Moore—Crane
209 A. M'Kenzie—Hinge for the heads of barouches, landaus, and other carriages
210 M. S. M'Callum—Hats and other coverings for the head
211 T. Bradford—Washing, wringing, mangling, and churning
212 S. Vaile—Tables
213 A. Brown, Le G. Kniffen, & T. H. Dodge—Mowing and reaping
214 W. E. Newton—Governors for regulating the speed of steam engines
215 L. Lindley & F. Taylor—Sewing, whipping, embroidering, and fringing
216 J. Stuttaford—Organs
217 H. Bessemer—Projectiles

Dated January 26th, 1864.

218 G. Darlington—Zinc white
219 R. Martindale & J. Williams—Lamps
220 R. A. Brooman—Bolting mills
221 J. Combe & J. H. Smalpage—Power looms
222 W. Norton—Weaving cut pile fabrics
223 H. C. Huskinson—Buttons
224 P. Christie—Building of wooden ships, vessels, and boats
225 J. H. Johnson—Stopping bottles containing aerated liquids

Dated January 27th, 1864.

226 J. Zacherl—Destroying insects
227 J. Young & A. C. Kirk—Motive power engines
228 W. E. Gedge—Steam engine
229 J. Cedge—Ploughs
230 T. Butterworth—Cutting manufactured and leaf tobaccos
231 S. Grafton—Apparatus for assisting persons in entering and alighting from vehicles
232 F. Parkes—Horse-shoe nails
233 E. Atkins—Fastenings for brooches, sleeve-links, solitaires, and belts

Dated January 28th, 1864.

234 W. T. Bury—Forming moulds for casting steel and other metals
235 J. Fry—Mechanism to be used in the mashing process when brewing or distilling
236 E. W. James—Raising sinking or submerged ships
237 J. Rodgers—Railway and road wheels
238 W. E. Newton—Soap
239 J. Henson—Railway goods' waggons

Dated January 29th, 1864.

240 W. Winter—Shaping machines
241 N. J. Holmes—Regulation of machinery for covering and twisting purposes
242 H. A. Bonneville—Anchors
243 H. A. Bonneville—Arithmometer
244 G. Canouil—Alarum
245 S. Dixon & J. Calvert—Stays and corsets
246 J. Kershaw—Weaving
247 W. E. Maude—Steam engines
248 H. A. Davis—Printing
249 B. l'Anson Bromwich—Casks
250 T. M. Heathorn—Separating liquids from solid substances
251 J. Marshall—Presses for the expression of oil and other fluids

Dated January 30th, 1864.

252 P. A. L. de Fontainemoreau—Stays and other articles of wearing apparel
253 R. B. Thomson—Carts and waggons
254 A. Tozer—Hand pumps
255 N. Fellows—Apparatus for the cure of smoky chimneys
256 D. A. Burr—Springs for railroad carriages and other purposes
257 J. C. Haddan—Fire-arms
258 J. Phillips—Cylinders for piers, embankments, and coffer dams
259 R. Brazier—Fire-arms
260 E. T. Hughes—Submarine batteries
261 J. Whitworth—Projectiles
262 W. Clark—Railway break
263 W. Clark—Effecting the combustion of certain matters for heating purposes
264 E. Myers & H. D. Gloag—Rotary pumps
265 H. Bessemer—Armour plates
266 W. E. Newton—Aluminium

Dated February 1st, 1864.

267 J. G. Jones—Getting coal
268 A. Prince—Artificial pavement
269 W. N. Hutchinson—Construction of cylinders of hydraulic machines
270 C. J. Rowsell—Apparatus for viewing photographic and other pictures
271 E. Harrison—Fire-arms

Dated February 2nd, 1864.

272 J. Clegg, J. Smith, & W. Carnelly—Weaving fabrics
273 J. O. Winkles—Fastenings for belt clasps, bracelets, and necklets
274 D. Anderson—Manufacture of curtain and other rings
275 F. E. Martineau—Hooks and plates of hook hinges
276 W. H. B. Castle—Composition for coating and insulating
277 R. A. Brooman—Glass
278 P. W. Gengemhre—Buttons
279 S. Ferguson, jun.—Lace
280 J. & C. Hawkins—Manufacture of gas for illumination
281 G. Hammond & J. W. Kemp—Illuminating gas
182 A. B. Childs—Lifting jacks

Dated February 3rd, 1864.

283 E. Beanes — Preparing or treating animal charcoal
284 J. W. D. Brown & J. Williams—Improvements in gas burners
285 J. Smith—Rendering doors and windows water-tight
286 W. & W. H. Watson—Blue colour for dyeing and other purposes
287 F. W. Webb—Cutting or shaping metals and other materials
288 T. Beams—Construction of valve gearing to steam engines
289 A. J. Walker—Improved clothes hanging apparatus
290 J. Durrant—Improvements in egg boiling apparatus

Dated February 4th, 1864.

291 H. Gardner—Arrangements for writing or marking instruments
292 H. E. Drayson—Gunpowder
293 G. T. Key—Percussion caps, lubricating wads, and tubes for ordnance
294 G. H. Holloway—Blocks for printing
295 R. A. Brooman—Stenographic apparatus
296 I. Edwards—Saddles for supporting articles of earthenware and china
297 T. Newton—Fire-arms
298 G. Davies—Apparatus for facilitating aerostation
299 J. Young—Preservation of vegetable and animal matters
300 S. Bark & T. Attwood—Improved slide for gaseliers

Dated February 5th, 1864.

301 E. Lucius — Separation and purification of colours
302 M. A. F. Mennons—Construction of sewing machines
303 J. C. Dickinson—Drying cylinders of machinery for sizing and drying yarn
304 J. Cooper—Sewing machines
305 J. Lee & J. Thomson—Mounting photographic and other pictures
306 J. Lee—Improvements in mill straps or driving belts
307 R. Owen—Filtering water
308 R. A. Brooman—Breaks for railway and other wheels
309 R. A. Brooman—Manufacture of bonnets, caps, and hats
310 Sir J. S. Lillie—Propulsion by atmospheric pressure
311 H. Gurney—Fire guards

Dated February 6th, 1864.

312 M. Runkel—Hinges
313 B. Lupton, S. & J. Whittaker, & E. Hartley—Steam engines
314 T. Eccles—Windmills
315 W. Taylor, W. Molinenx, & H. Harrison—Puddling furnaces
316 A. M'Laine—Construction and equipment of vessels of war
317 J. Kaye—Manufacture of oil cans for lubricating purposes
318 G. T. Bousfield—Improvement in feathering paddle wheels
319 C. Mather—Improvements in manndrills for printing rollers
320 M. C. de Casteras Sinibaldi—Plates, tubes, and cylinders
321 H. A. Fletcher — Locomotive engines and tenders
322 W. R. Taylor — Improvements in brewing utensils
323 S. W. Mulloney & G. Johnson—Frillings or ruffles
324 J. T. Oakley—Vertical steam boilers or generators

Dated February 8th, 1864.

325 R. H. Napier—Screw steamers for naval warfare
326 T. Snowdon—Improvements in steam engine cylinders
327 D. Pidgeon & W. Manwaring—Reaping and mowing machines
328 N. M'Haffie—Improvements in the manufacture of cast wheels
329 F. A. Laurent & J. Casthelaz—Violet colouring matters
330 A. G. Brown—Registering the quantity of air expired from the lungs during respiration, forced or natural
331 E. Welch—Improvements in tobacco cutting machines
332 J. Webster—Improvements in the preparation of paints or varnish
333 J. Eastou, jun., & T. Leigh—Manufacturing paper
334 V. de Stains & T. Rogers—Machinery for sewing and stitching

Dated February 9th, 1864.

335 J. C. B. Salt—Protecting iron ships and vessels from corrosion
336 J. Smith—Machinery for combing cotton and flax
337 R. J. Cunnack—Cartridges for blasting and projectile purposes
338 W. C. Stobart—Coke ovens
339 J. Toussaint—Manufacture of cement and artificial stone
340 W. Clark—Apparatus for inhaling air when charged with vapours
341 B. Todd—Compositions to prevent the oxidation of iron
342 A. M. Perkins—Warming rooms and buildings
343 F. W. Webb—Improvements in the manufacture of railway rails
344 T. S. Cressey—Apparatus for screening barley and other grain
345 J. H. Johnson—Improvements in motive power engines
346 P. Spence—Sulpho-cyanide of ammonium and other sulpho cyanides
347 A. V. Newton—Securing tubes in the tube sheets of steam boilers and condensers
348 A. V. Newton—Obtaining and transmitting power

Dated February 10th, 1864.

349 J. B. Borgatta—Motion lever of the second order
350 W. Carnelly—Manufacture of looped and cut pile fabrics
351 M. C. de Casteras Sinibaldi—Coating ships and other structures
352 S. Middleton—Deadening the noise produced by engines and carriages in passing along railway bridges and viaducts
353 H. D. P. Cunningham—Fittings of gun carriages
354 W. Hawthorn—Joints for pipes, tubes, and hollow vessels

Dated February 11th, 1864.

355 T. V. Lee—Construction of kilns or retorts for cooking
356 R. Smith—Forging or shaping cranks on bars of metal
357 J. M. Faget—Apparatus for taking up the emanations and the gases from boilers
358 G. Davies—Improvements in the manufacture of sulphuric acid
359 J. H. Johnson—Measuring, raising, and forcing liquids
360 J. H. Johnson—Improvements in the manufacture of superphosphates
361 A. & E. M. Denny—Improvements in the manufacture of bacon
362 J. Keats & W. S. Clark—Manufacture of boots and shoes
363 P. A. L. de Fontainemoreau—Photographic apparatus
364 J. Stack—Filtering marine and other water or condensed steam

Dated February 12th, 1864.

365 I. Dimock—Combing cotton and other fibrous materials
366 J. David—Improvements in thrashing machines
367 J. W. Wetherell—Improvements in pullies and riggers
368 T. White—Machinery for uniting the soles and uppers of boots and shoes
369 J. Henderson, S. C. Child, & W. L. Duncan—Improvements in rails for railways and tramways
370 W. Winstanley & J. Kelly—Steam apparatus for ships' use
371 W. E. Gedge—Improved fire arm and projectile
372 W. Drake—Improvements in the manufacture of iron
373 J. Hicks—Barometers
374 W. Southam—Improved apparatus for drying grain
375 F. W. Burton—Improvement in articles of furniture
376 W. Riddle—Improvements in fire-proof buildings
377 T. Smith & T. Lister—Machinery for transmitting power
378 W. Norton—Power looms

Dated February 13th, 1864.

379 J. Bedford—Certain improvements in locks or similar fastenings
380 T. Jackson—Certain improvements in braiding machines
381 G. Finch—Applying steam or other fluid pressure acting on a piston to produce circular motion
382 W. Whiteley—Stretching woollen and other fabrics
383 W. Krutzsch—Punching, shearing, rivetting, stamping and pressing
384 W. Anderton — Preparing, spinning, and doubling cotton, worsted, and silk

Dated February 15th, 1864.

385 J. Dence—Improved combined water closet and urinal
386 A. Steinmetz—Intensifying the light of horizontal gas burners
387 P. A. L. de Fontainemoreau—Manufacture of methylic ether
388 G. Haseltine—Bridge
389 G. Bohn—Improvement in cowls for chimnies and shafts
390 H. W. Wood—Cylinders exposed to the direct action of fire
391 J. Huntington—Improvements in the construction of printing rollers
392 W. Hensman—Improvements in cultivating land
393 S. Darby—Improvements in the manufacture of dough and bread

Dated February 16th, 1864.

394 H. & J. Andrews—Attaching buttons to garments
395 W. C. Fuller—Rendering doors and windows water tight
396 J. E. Tuchet—Improvements in apparatus for cleaning windows
397 R. St. L. Pigot—Breech and muzzle-loading cannon guns and other fire-arms
398 W. Clark—Improvements in the permanent way of railways
399 F. C. P. Hoffman—Machines for crushing hard substances, for washing ores and minerals, and for separating earth and earthy matter from solid substances
400 A. J. Joyce—Steam engines
401 J. & M. Deavin & J. H. Sutton—Obtaining oscillating or swinging motion in swings, cradles, cots, and other like articles

Dated February 17th, 1864.

402 J. A. Lloyd—Improvements in cases for packing
403 J. Wadsworth—Softening or dissolving animal matters
404 F. Testuz—Brake applicable to locomotives, railway and other vehicles
405 W. Hobbs—Railway signal
406 E. Moore—Improvements in the manufacture of surgical bandages
407 H. A. Jowett—Fixing rails for the construction of the permanent way of railways
408 H. Newmane—Compound pill for diseases of the liver
409 J. Aisthorpe—Construction of ordnance and fire-arms
410 J. Weeks—Improvements in parasols and other like articles
411 C. P. Coles—Fastenings for armour plates on ships
412 W. Hawkins — Improvements in pumps of hydraulic presses
413 R. Hornsby, J. Bonnall, & W. Astbury—Agricultural implements
414 H. Y. D. Scott—Improvements in the manufacture of cement

Dated February 18th, 1864.

415 J. R. Hoffman—Apparatus to release instantly any vehicle when the horses run away
416 C. Field—Improved method of manufacturing ladies' stays
417 E. Watteen—Railway spikes, rivets, boltblanks, and other similar articles
418 L. S. Naudin—Preparation and composition of a substance for soldering silver
419 J. Travis—Preventing and curing corrosion and preserving the metal in steam boilers, steam generators, and fuel economisers
420 R. C., R. J., & J. E. Ransome—Beams, mould boards, and shares of ploughs
421 A. Applegath — Improvements in printing machines
422 J. W. Harold—Apparatus for stretching or altering hats
423 W. Hickling — Bobbin net and twist lace machines
424 F. M. A. de Tregomain—Rendering fire wood and other materials more combustible
425 E. Butterworth — Improvements in gins for ginning cotton
426 J. B. Jude—Improvements in cask cleansing machines
427 J. W. Browne—Excluding dust, wind, and moisture from windows, doors, and other parts of buildings
428 R. S. Symington—Apparatus for climbing, and the elevation and support of weights

Dated February 19th, 1864.

429 E. J. Leonard—Raising, lowering, or hauling weights
430 G. H. Johnson—Constructing lighthouse towers and other buildings
431 J. J. Chidley—Rendering air tight bottles and jars
432 F. J. Arnold—Producing and burning combustible gases
433 T. Jackson—Manufacture of coiled or helical springs
434 W. Jones—Governors or regulators for steam engines
435 R. Scrivener—Preparation of clay and other plastic materials
436 W. C. Page—Composition for coating ships' bottoms
437 W. Hale—Ordnance

Dated February 20th, 1864.

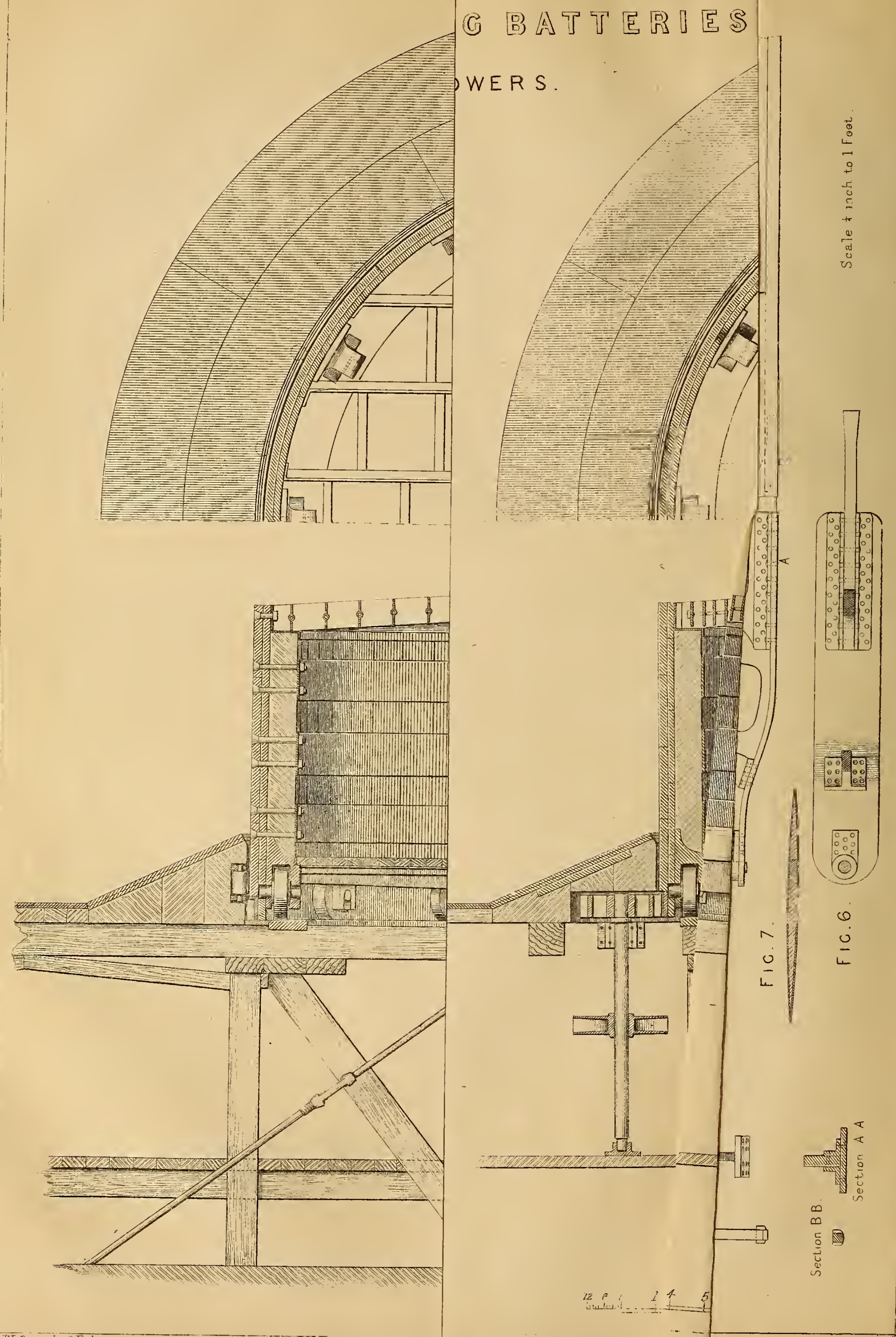
438 J. Hayworth—Construction of permanent way of railways
439 E. E. Allen—Construction of locomotive and portable engines

Dated February 22nd, 1864.

440 J. Gerstenberger—Condensing steam and utilising the heat thereof
441 W. E. Gedge—Improved kind of photographic album
442 F. R. Mosley—Lamps for railway and other carriages
443 H. C. Gamble—Lowering, detaching, hoisting, and securing ships' boats
444 W. Brookes—Metallic permanent way of railways
445 J. Rigby—Improvements in the projectiles and wads of fire-arms
446 A. V. Newton—Photography
447 G. P. Gee & W. H. Gosling—Machinery for sewing and stitching
448 J. Drabble—Improvements in the manufacture of bobbin net
449 J. Oldknow & J. Wood—Jacquards used with lace machines
450 S. S. Maurice—Manufacture of buttons, studs, and other appendages to wearing apparel

G BATTERIES

WERS.



W Smith, C.E direx

THE ARTIZAN.

No. 16.—Vol. 2.—Third Series.

APRIL 1st, 1864.

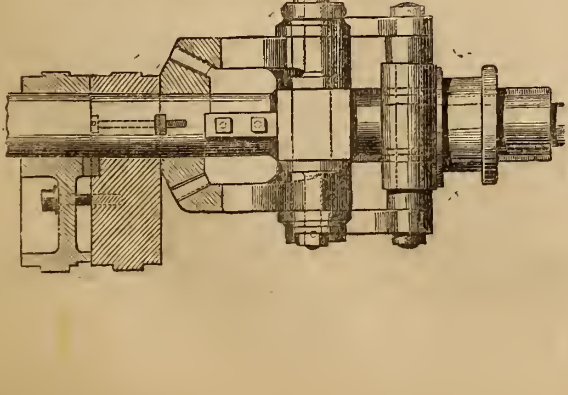
UNITED STATES' IRON-CLAD STEAM FLOATING BATTERIES OR MONITORS.

(*Illustrated by Plate* 259.)

Agreeably to the promise contained in our issue of last month, we present our readers with the accompanying copper-plate engraving, illustrative of the revolving tower or turret, and propeller and stern arrangement of one of the American monitors, Fig. 1 being a half sectional plan of the turret, showing the deck and framing thereof. Fig. 2 is a half plan of top of turret, showing also the guide rollers. Fig. 3 is a transverse section of the turret, gun, and gun platform, showing the supporting wood framing of turret and diagonal wrought iron stays. Fig. 4 is a longitudinal section of the turret, showing the turning gear and the gun mounted on platform. Fig. 5 is a longitudinal section of the aft portion of the vessel, showiug the rudder, propeller, and stern arrangement; Fig. 6 being a plan of the foot-plate. Fig. 7 shows a cross section of the rudder, Fig. 8 is an end of the stern-post, and Fig. 9 is an end view of the wrought iron post aft of the propeller, for supporting the foot-plate on which the lower step of the axis of the rudder rests. The rudder is equipoise, 28in. wide forward of the axis and 56in. aft; height 8ft., made of wrought iron. The centre piece of the rudder has arms forged at the top and bottom for supporting the plating, as shown in Fig. 5 of the accompanying plate. A wrought iron post, 3in. by 7in., is firmly rivetted nnder the curved overhanging part of the vessel, for supporting the plate on which the lower step of the axis of the rudder rests. The upper end of the axis passes through a stuffing-box, terminating with a square, to which the tiller is applied.

The stern-post is made of hammered iron, forged in the form of a knee, the arm extending 6ft. into the knee (measured from the after face of the post). The post to be 4in. thick, 9in. deep, having a "shaft eye" forged forged in and bored 16in. diameter; the external diameter to be 22in. The axis of this "eye" is not at right angles to the post, but bas an inclination towards the knee (forward) of 1in. in $74\frac{1}{2}$in. The afterside of the "eye" is faced off at right angles to the bore. The arm of the post is made to conform to the shape of the after length of the knee, aud is securely rivetted thereto. A portion of this "arm" is 13in. deep diminishing by an ogee curve to 4in. deep at the end, along the bottom of the "stern post arm" for a distance of 3ft. forward, and 1ft. aft (measured from the face of the post). There are rivetted two bars of 6 × 6 angle iron (the projecting legs to be flush with the bottom of post arm) forming a surface 16in. wide, 4ft. long, to which is fastened the beam or foot-plate for carrying the rudder-step; the beam or foot-plate being formed of two thicknesses of 1in. plate, 24in. wide. These plates being of suitable length to receive the rudder post-step, and are well rivetted together. The upper end of the stern extends to the underside of deck, and is fastened to the deck-beam by two vertical bars, 4 × 4 × $\frac{1}{2}$ inch angle iron, 12 inches long, rivetted on the sides of a post, and bolted through and through the beam. This post has two $1\frac{1}{2}$in. holes drilled near the head for the purpose of receiving the feet of two braces, which are carried over to the sides of the boat to give strength to the projecting hip.

The accompanying woodcuts, Figs. 1, 2, and 3, illustrate the reversing gear for the engines of the *Monitor* and *Gallena*:—



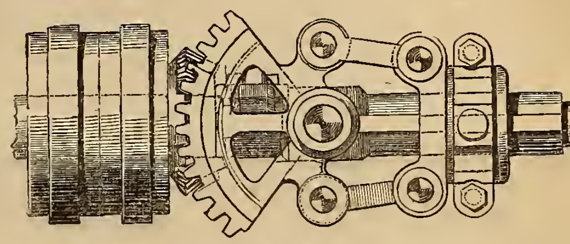


Fig. 2.

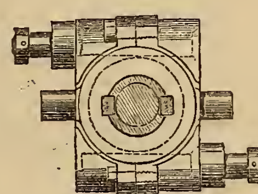


Fig. 3.

REPORT ON THE EMBANKMENT OF THE BRADFIELD RESERVOIR, AND ON THE PROBABLE CAUSES WHICH LED TO ITS FAILURE.

The following interim report has been made to us by Mr. Birckel, who was specially commissioned to make a personal investigation, and report to us. The shortness of the time, however, before going to press, only allows of our giving a portion of the report, which, brief as it is, will, with the aid of the diagrams, render the subject perfectly intelligible to our readers. We defer until our next the completion of the report and illustrations.

The Bradfield Reservoir forms part only of a very comprehensive scheme for pounding in the waters of several small streams which together make up the river Don, the lower portion of the valley which, before it enters the town of Sheffield proper, has witnessed the late destructive flood. This scheme consists in pounding up the excess of water during the rainy seasons in four reservoirs, namely, the Bradfield, the Agden, the Redmires, and the Rivelin, each of which is situate in a separate valley, the Bradfield being the most extensive of them all, and placed at the upper end of the valley of the Don proper, where, however, that river has changed its name already, and is known by the name of the river Loxley, or the Dale Dyke. The object of impounding these waters is not, as probably is supposed by strangers to this locality, to supply the town of Sheffield with water for domestic purposes, but to supply the mills which have been established on the banks of the Don with an adequate measure of water power at all seasons of the year however dry. It will thus be perceived that the object in view being the utilization of power which would otherwise be lost, and in so far the creation of a greatly increased amount of wealth.

The Bradfield Reservoir which, as has been stated, impounds the waters of the Loxley, forms in plan a long triangle, as shown by the accompanying sketch Fig. 1, the sides of which run along the opposite slopes of the hills on each side of the valley, and the base of which forms the embankment, the subject of this inquiry. In the accompanying woodcut the part covered with diagonal lines show the outline of the reservoir. The dotted lines indicate the outline, *b c*, proposed for the reservoir as originally intended; *b* the site of the originally-intended embankment or dam.

The embankment, as has been stated by the engineer of the whole scheme (Mr. Leather), is about 1,250ft. long, and 95ft. high at its greatest height, its width at the crown is about 15ft., and the slopes on both sides, 1 in $2\frac{1}{2}$, which gives a width of 490ft. at its base. Originally, it had been intended to throw the embankment across the valley at a point some 350

U.S. STEAM FLOATING BATTERIES.

REVOLVING TOWERS.

Fig. 1

Fig. 2

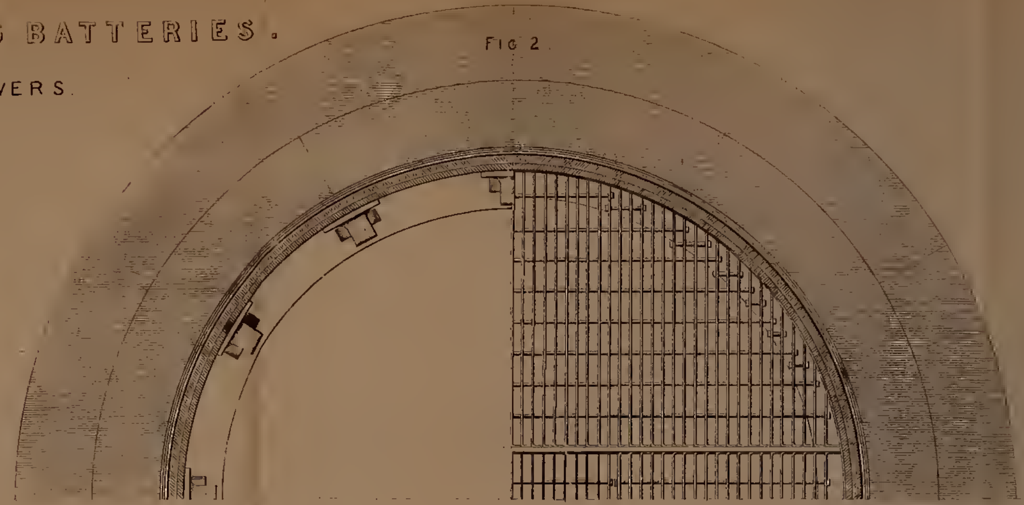


Fig. 3

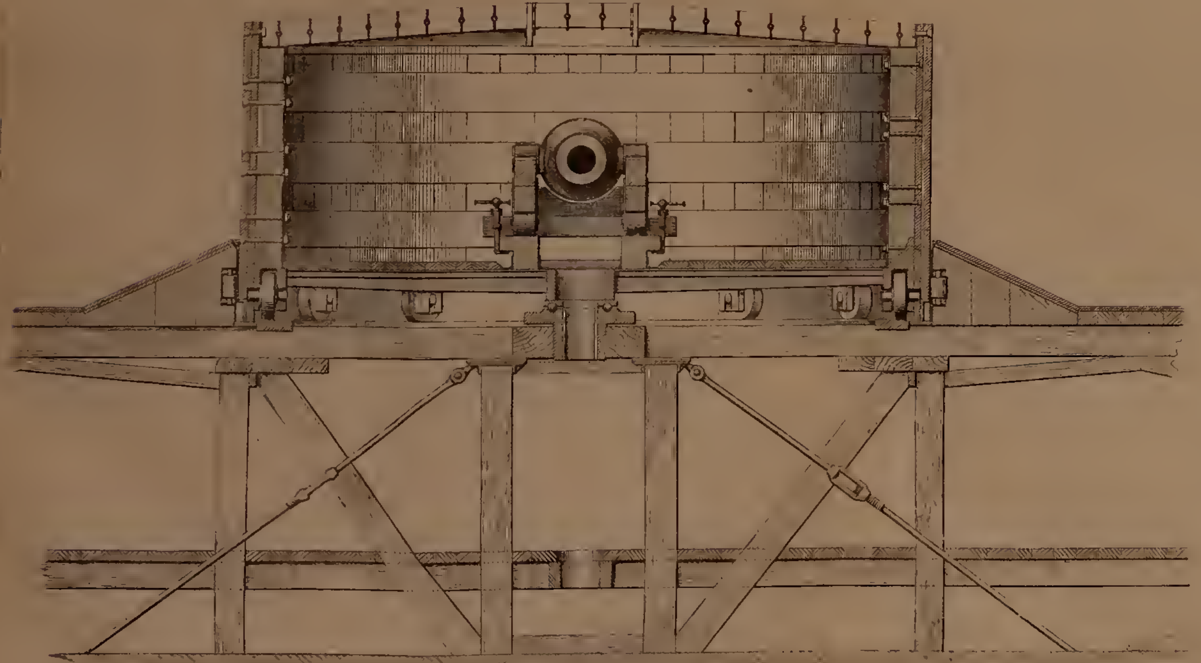
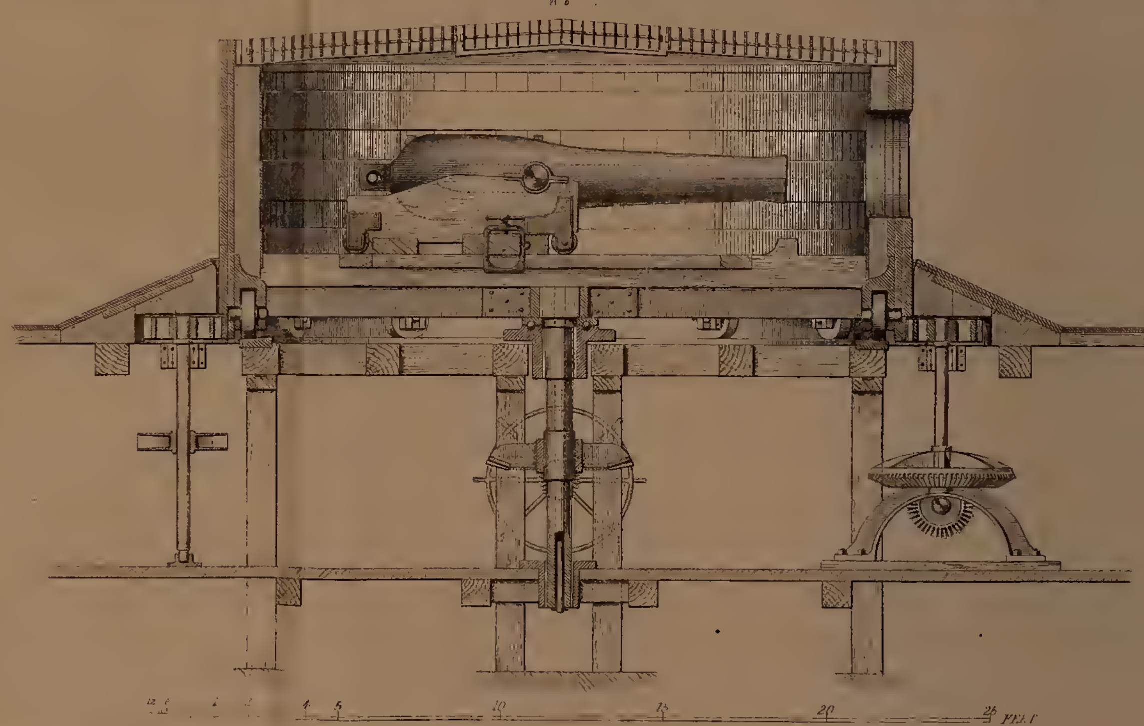


Fig. 4



RUDDER PROPELLER & STERN ARRANGEMENT.

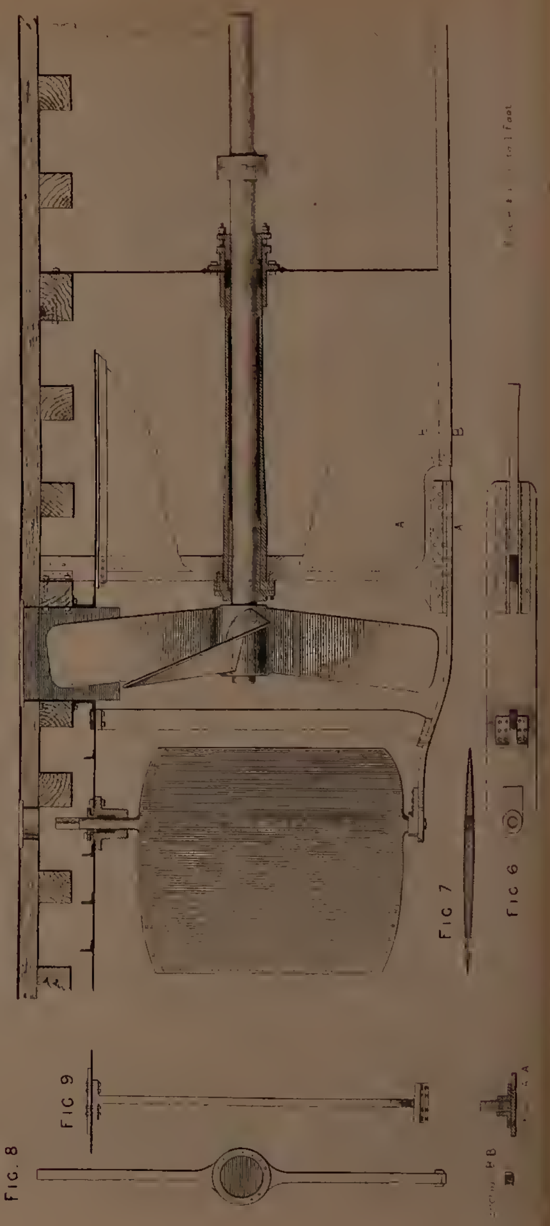


Fig. 5 Fig. 6 Fig. 7 Fig. 8 Fig. 9

Fig. 1.

yards lower, but upon examination of the substrata, by means of borings, the foundation there was deemed unsafe, and the site where the embankment now stands was ultimately decided upon. In designing the same, the engineer has adhered to what seems to be the usual practice; namely, that of raising a puddle wall longitudinally in the centre of the embankment of a thickness proportionate to its height, and of raising on each side of it a wall of earth, stone and shingle, or some of these materials, of an aggregate weight equal to ten times the pressure they will have to bear, and with such slopes as may be required by the nature of the materials employed. Whether the intentions of the designing engineer are always carried out by the contractor, or whether they are always enforced with rigidity by the superintending engineer, and if not, upon what considerations these intentions as embodied in a specification previously drawn up are evaded or disregarded, we do not here propose to inquire; but, inasmuch as this work has failed upon the very first time when it was called upon to resist the pressure which it had been designed to resist, it is right, on purely technical grounds, to see whether the work had been carried out according to specification, and also to inquire whether the principles of the design are in any way defective.

Upon examination of the material forming the puddle wall, which has been done with great care, digging into the very centre of it, we found it to be perfectly plastic and homogeneous, capable, with its thickness of some 12ft. at the point where we examined it, to act as a water resisting wall, under almost any head of water, and in this respect our opinion is borne out by that of the Government Commissioners (Messrs. Rawlinson and Beardmore), who expressed similar views on that portion of the ill-fated structure. Different, however, were our impressions on examining, as far as that could be done, that portion of the work which constitutes the embankment proper. This appears to have been constructed in layers of 6ft. in thickness, the materials being chiefly broken stone of convenient weight for hand loading into waggons, with a rather scanty admixture of earth, and tipped out of the waggons without the care of any after adjustment to cause the stones to have a proper bearing, and to make the whole structure as compact as with such material it could be made; but, on the contrary, these were left anyhow, just as they would roll upon being tipped out of the waggons, leaving, perhaps, between each three or four stones a hollow cavity of a cubic foot or more. Thus the appearance of the embankment, seen in cross section (and as illustrated in the accompanying woodcut, Fig. 2,

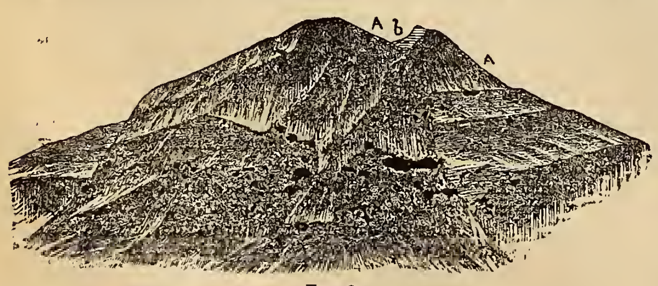


Fig. 2.

showing a cross view of the gap looking at the southern portion, A A being the stone pitching; *b* gap produced by the sinking of the bank) by the extensive gap scoured out at the point where it gave way, reminds the observer rather of a huge sieve (saving of course the puddle wall) than of a structure designed to impound safely and permanently the enormous mass of 114 millions cubic feet of water. Nor did we confine our observations to the external examination of the Bradfield embankment, but, guided by the principle that like produces like, we went to examine the Agden embankment now in course of construction under the same engineers, and we presume by the same contractor, and the work, as there being carried out, far surpassed in its looseness and imperfections anything that we might have been inclined to conjecture by the appearance, in cross section, of the Bradfield dam. Now it appears, from what has been said at the late inquest, that the specification limits the layers to 3ft. in thickness; but these layers, which may be plainly observed in the Bradfield dam, are certainly not less than 6ft. in thickness, and in the Agden embankment they do not fall much short of 8ft.; under these circumstances, we have reason to be surprised at the statement made by Mr. Leather, that "so far as his observations went the work was good throughout," and, again, that "he did not attribute the failure either to bad principles of engineering or bad workmanship." Mr. Rawlinson in his evidence did not omit to make due mention of the looseness of the work and to condemn the plan of carrying it forward in layers of such great thickness, especially with material like that which is there being used.

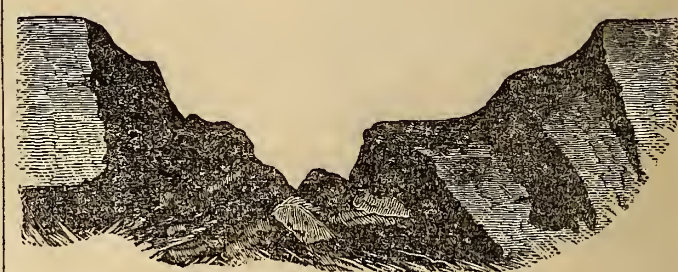


Fig. 3.

The woodcut, Figure 3, shows a view in front of the embankment, showing the outline of gap.

Fig. 4 is a view showing part of the reservoir and the dam or embankment, with the gap made in it.

Having thus reviewed the nature and quality of the work, we now procced to examine the principles of engineering upon which the design of the embankment is based. These principles have been very clearly, and we think very correctly, defined by Mr. Leather in his evidence, when he stated—1st. That the puddle wall is the real impounder of the water. The only object of the embankment is to support the puddle wall. 2nd. The embankment is made on the principle that its weight be ten times the pressure against it.

Now when the law is laid down that the puddle wall is the real security of the water, and that the object of the embankment is to support it, subject to the condition that the weight of this support be ten times the pressure against it, and that of course at every point—or at every infinitessimal layer—in the height of the embankment, the question naturally arises, Is the centre of the embankment the proper place for the puddle wall? The answer to this question in our opinion and to our mind is clearly and emphatically, No; for if the entire section of the embankment represents the total weight of material actually wanted to resist the pressure, it is evident that the inner half of it is entirely ineffectual as a resisting medium, and at best acts as a protection to the puddle against abrasion by the action of the water in rough weather, or other accidental causes; while, at the same time if it is permeated by the water, and the earthy

portions of its constituent elements are rendered semi-fluid, then is this inner half an additional weight, partly to be supported by the outer half of the embankment, and instead of having a resisting mass equal to ten times the pressure of the water, it becomes a question whether the resisting mass is equal to twice that weight, in which case the least disturbance of the surface of the water would sweep the embankment down to the entire depth of such disturbance, an event which must of necessity lead to a catastrophe such as that which has taken place at the Bradfield embankment. That, we are inclined to believe, furnishes a more plausible argument in explanation of the failure of the said work than the one of a disturbance of the nether structure, or foundation of the dam as conjectured by Mr. Leather, and the peculiar looseness and sieve-like construction of the work strongly militates in favour of our view.

It would, however, be contrary to the rules of professional propriety to find fault with the designing engineer for following the example of those who have successfully constructed works of this kind on the same principle, and our remarks are rather made as a suggestion than as tending to criminate him.

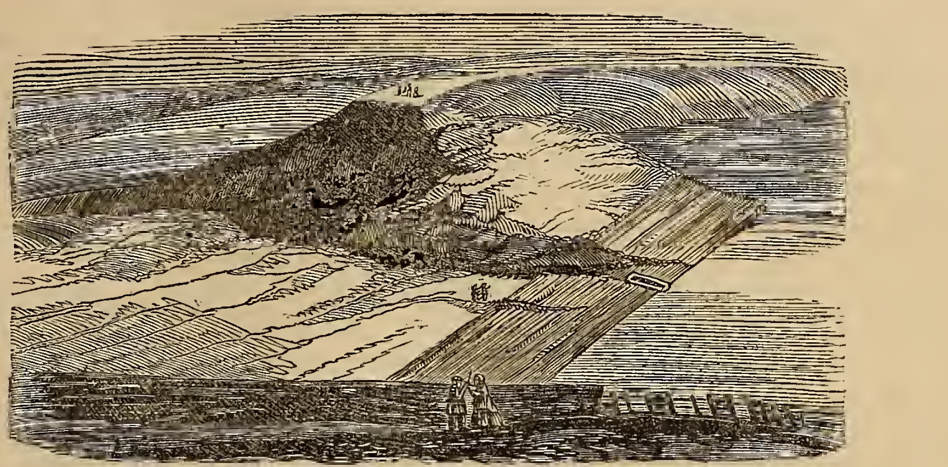


FIG. 4.

To complete our remarks respecting the principle of construction of an embankment of this kind, and in order to be clear and definite in our suggestions, we shall say that, in our opinion, the proper place for the puddle wall is on the inner slope of the embankment proper, covered with so much material only as may be required to prevent its being injured either by atmospheric influences or by the destructive agency of animals burrowing under water such as water rats.

Passing now to the consideration of that particular detail in the scheme of the reservior upon which its entire success must ultimately depend, namely, the provision for drawing the water off when it has been impounded, we must confess to the great surprise which we experienced upon learning, first, that the only means of drawing off the enormous bulk of 114 millions cubic feet of water consisted of two 18in. pipes; and secondly, that these pipes were imbedded into the base of the embankment—protected, it is true, by a puddle trench—but in such a manner as to render it impossible to get to them for the purpose of examining the joints, if at any time that be required, without cutting down the embankment.

The practice of the engineers to the Mersey Dock estate, and other equally practical folks, is to lay all their water and gas mains which have to be carried across dock entrances in cast iron culverts of from 4ft. to 4½ft. diameter. That any engineer would be guilty of such want of foresight as has been practised at the Bradfield dam we should have utterly discredited it, had the fact not been disclosed in evidence before the coroner's inquest. The attitude assumed by the designing engineer, Mr. Leather, when examined upon this point by the Government Commissioners is anything but creditable, in our opinion, to a professional man who has been entrusted with the execution of a work of such magnitude. What are we to think of his statement, that, "His experience is, that pipes scarcely ever give way at the joints and leak," when scarcely a day passes in any of our large cities, without disclosing some leaky joint or fractured pipe in the water mains or service pipes supplying our domestic wants, although these are not subject to the crushing pressure of an embankment 90ft. high, nor yet liable to the deflection which would be caused by the almost inevitable settlement of the ground upon which they are bedded when such a weighty structure has been reared upon it.

In the same portion of his evidence, Mr. Leather also stated "that the two 18in. pipes would discharge 10,000 cubic feet per minute, and would empty the reservoir in about eight days, supposing there was no addition," which statement is so erroneous (as we are about to show), that we are rather surprised the Government Commissioners, who laid great stress upon the inadequacy of the provision for letting off the water, did not challenge those figures.

Taking the maximum head of water at 90ft., the velocity of discharge would be

$$V = 8\sqrt{90} = 76\text{ft. per second},$$

the area of the two 18in. pipes, 3·55 square feet, and the total discharge per minute under the maximum head

$$76 \times 3{\cdot}55 \times 60 = 16200 \text{ cubic feet theoretical},$$

allowing 10 per cent. for contraction of vein there remains 14,580 cubic feet; but inasmuch as the mean discharge, under a constantly diminishing head, is only one half the discharge which would take place under constant head in a given time, this discharge will only be 7,290 cubic feet, instead of 10,000 as stated at the inquest, and would take eleven days, instead of eight, to empty the reservoir. It is true that the law of reduction of the discharge to one half under a constantly diminishing head is strictly correct, only so long as the ratio of the area of the reservoir to the area of the discharge orifice remains constant, and although in this case that condition is not altogether realised, yet the variation of this ratio, as due to the slopes of the banks, cannot affect the rate of discharge in the ratio of 3 to 4¼, especially when account is taken of the probable obstructions round the valves which may prevent the free outflow of the water.*

In order to ascertain what amount of faith attaches to Mr. Leather's theory, that the failure of the dam was occasioned by a slip of the substrata of the soil upon which it rests, we have carefully examined the ground for a considerable distance around the embankment in the hope of

* For those who may wish to have a demonstration of this law of reduction of discharge we here append it. Let A be the area of the reservoir, and $d\,x$ an infinitesimal portion of the head (H) of water, then A $d\,x$ will represent the volume of water for the depth $d\,x$; let a represent the area of the discharge orifice, x the head of water at any given time while the reservoir is emptying itself, then $a\,.\,\sqrt{2\,g\,x}$ will represent the volume discharged per second with that particular head, and the time $d\,T$ in seconds will be

$$d\,T'' = \frac{A}{a\,.\,\sqrt{2\,g}}\,.\,x^{-\frac{1}{2}}\,d\,x \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1.)}$$

which by integration becomes

$$T'' = \frac{A}{a\,.\,\sqrt{2\,g}}\,.\int_{H}^{o} x^{-\frac{1}{2}}\,d\,x = \frac{A}{a\,.\,\sqrt{2\,g}}\,.\,\frac{x^{1-\frac{1}{2}}}{\frac{1}{2}} = \frac{2\,A}{a\,.\,\sqrt{2\,g}}\,.\,\sqrt{H} \quad (2)$$

when, however, the factor $\sqrt{2\,g\,x}$ remains constant and equal to $\sqrt{2\,g\,H}$, then the integration of formula (1) becomes

$$t'' = \frac{A}{a\,.\,\sqrt{2\,g}}\,.\,H^{-\frac{1}{2}}\int_{H}^{o} d\,x = \frac{A}{a\,.\,\sqrt{2\,g}}\,.\,\sqrt{H}$$

or $T'' = 2\,t''$ so long as $\frac{A}{a}$ remains unchanged.

finding some traces of such an indication in the shape of cracks in the surface of the soil, but have been unable to find any except such as have been caused by the flood along the margin of its track; this attempt at accounting for the failure must, therefore, fall to the ground unless it can be shown that a subterranean slip can take place without betraying itself on the surface—a phenomena which seems to us perfectly impossible. This theory, however, assumes a still greater degree of unlikelihood when it is attempted to establish the fact, that such a slip should have been felt by a portion of the embankment only of some 300ft. in length, and hard upon the slope of the northern side of the valley, without betraying itself upon the surface soil of that slope which afterwards gave way under the effects of the flood, and at a considerable distance from its track.

While examining the ground, however, for the purpose just named, to our great surprise we discovered a copious stream, which we traced up the north slope of the valley to a height of some 100ft. above the upper level of the embankment, discharging itself into the old bed of the Dale Dyke (or Loxley) close behind the foot of the dam, the ground along its track for a considerable distance up the slope being a perfect bog or moss. It is not at all unlikely, therefore, that this stream, which would be very considerable after rainy weather, has so soaked the foot of the dam, which happens to have given way just at the place where it rested upon the old bed of the river, as to cause it to slip, and this especially so if the other concomitant causes already enumerated were favourable to such an effect. In our opinion, at any rate, the engineers of this work have laid themselves open to the charge of unpardonable neglect for not draining the ground immediately behind the base of the embankment; and we are rather surprised that the Government Commissioners have not called their attention to this fact.

These are the points which, in our opinion, deserve special attention in the examination of this work, and its failure must be accounted for by the internal evidence which it gives of bad workmanship and of carelessness in preparing the ground upon which that portion stood which has been swept away, without calling to assistance the far-fetched theory of an invisible subterranean slip, of which there is no evidence in support. What value the propounders of that theory attach to it in their own minds must transpire in due course of time, for if they really believe in it they have no choice but to abandon that work altogether, since, if the strata have slipped once, there is no reason conceivable why they should not slip again and again.

It is not our province to expatiate upon the feelings which force themselves upon the mind of the observer as he wends his way up the desolated valley of the Don, but we could wish that every engineer had an opportunity of witnessing the same, in order to obtain an adequate idea of the responsibilities which weigh upon his shoulders in the discharge of his duties, and to become impressed with the necessity of perfectly mastering the many difficult problems involved in the practice of his profession, in order to be able to bestow upon mankind the greatest possible amount of benefit, in return for the respect which his profession very justly exacts from his fellow-men.

THE LONDON ASSOCIATION OF FOREMEN ENGINEERS.

It will be seen from the report we have given that the anniversary of the above-named society was celebrated by a dinner at Radley's Hotel, on the 27th of February. One of the main features in the proceedings was the countenance given to it by various engineering employers. The fact that a gentleman so well known and so highly respected as Mr. Henry Grissell should have presided at the festival, is in itself of great importance, because it is a proof that the jealousy with which the society has been regarded by the heads of the engineering firms is wearing away, and that it is rather entitled to co-operation on their part than discouragement. It has, indeed, been matter of surprise to us that a society which, from its first establishment, has sought to effect nothing but the moral and material advantage of its members, should have ever laboured for a moment under the disapproval of engineering employers. In fact, as we have often thought, and as Mr. Newton, its president, clearly demonstrated in his speech after the dinner at Radley's, employers have derived great benefit from the friendly contact of their foremen at the monthly meetings of the society. Every one who is acquainted with the interior arrangements of engineering works—whether on a large or small scale—must be aware of the diversity of the operations conducted within them, and of the impossibility for the foremen of any one of those works to be master of *every* operation going on within it. Foremen engineers, as a general rule, are appointed to their various posts in consequence of their possession of great practical knowledge and skill; but it frequently occurs, nevertheless, that difficult tasks present themselves, and which, without a course of experiments, or communications from others who have met and surmounted similar obstacles, it would cost much time and money to overcome. This society meets completely such cases, for it enables foremen to assemble and take counsel together, and by the intercommunication of ideas, to arrive at the readiest way of solving mechanical problems, or of fighting successfully against practical impediments to the economical and efficient performance of their duties.

Are not such advantages, therefore, a palpable gain to employers, and do they not conduce to the improvement also of the employed? Surely, this position cannot be assailed, and as assuredly is it to the interest of employers to encourage the association of their leading assistants. We have, moreover, carefully examined the whole of the rules drawn up for the government of the Association of Foremen Engineers, and we cannot find among them one which, by any ingenuity, can be construed into being antagonistic to employers. On the contrary, they have been evidently framed so as to avoid even the semblance of such a fault. Manifestly, the founders of the society studiously guarded themselves, in instituting their code of laws, against the introduction of a single sentence which was adverse or unfavourable to the well-being of the heads of firms. In the preface to the rules of the society we find the following statement:—"The monthly meetings of the association are of a scientific character—papers being read thereat and discussions following them. These latter partake more of the practical than the theoretical, and they form media for the interchange of advice and knowledge gained by experience and experiment. To all its meetings employers are admitted, whether honorary or not. The association does not, on any occasion, discuss the politics of the trade. It has no secrets, but courts complete publicity for all its acts and sayings. Its objects are solely philanthropic and instructional." It does seem singular that so clear a renunciation as this is, of everything which might in the eye of the most illiberal of employers be deemed inimical to that body, should have been so long disregarded, and that it is only now when the society is in the twelfth year of a healthy existence that employers are beginning to recognise its merits and to give it their cordial support.

The remarks of Mr. Grissell on the occasion of the dinner demonstrate very conclusively that gentleman's high estimation of the usefulness of the association, whilst his promise to contribute, conditionally, £50 to its benevolent fund is a substantial mark of regard. The same may be said of Mr. Telford Field, and it may be trusted that other employers, now that the ice is fairly broken, will follow the example so worthily set, and subscribe the remaining £400, which is required to fulfil their excellent proposition, and to realise one of the main objects of the institution.

As this journal is one which appeals alike to employers and employés, and which knows of no diversty of interest between the two classes, we make no scruple about advocating the claims of the association in question, and which we affirm to be subsidiary to the prosperity of both.

Something was said by one gentleman—happily not an engineer—on the occasion of the dinner, about the society "suffering from the patronage of employers,"—a most ill-judged and ill-timed, not to say ill-natured commentary upon the liberal promises of Messrs. Grissell and Field, but one which is not, we are sure, sympathised with by any member of the association. In order to make plain the animus of Messrs. Grissell and Field in their conditional gifts of £50 each to the association, we quote part of one of its rules in reference to the application of its funds:—"Members of ten years standing, when by age or infirmity rendered unable to maintain themselves, shall, if the funded property of the association amount to £500, be entitled to receive a superannuation allowance of 5*s.* per week each." It is with a view to the realization of this arrangement that other employers are invited to contribute to the funds of the society, and we sincerely trust that the invitation will not be given in vain Benevolence is not "patronage," but a Christian virtue of universal application, and we can only pity those who regard it differently.

DOUBLE CYLINDER EXPANSION STEAM ENGINES.

In our article in THE ARTIZAN of last month we referred to the steamship *Quito* having made a very satisfactory run on her first voyage out to St. Vincent's. Since then we have received a copy of the abstract of her log as given below. It will be seen that a special feature in this vessel, in addition to her speed, is the lowness of her coal consumption.

ABSTRACT OF THE LOG OF THE PACIFIC STEAM NAVIGATION COMPANY'S ROYAL MAIL STEAMSHIP "QUITO," S. S. HOLLOWAY, Commander, FROM LIVERPOOL TOWARDS ST. VINCENT, COMMENCED AT 3.12 P.M., 27TH JANUARY, 1864, AND ENDED AT 6.45 A.M. 5TH FEBRUARY, 1864

Date.	Draught of Water. Forward.	Draught of Water. Aft.	Winds.	Courses.	Distances.	Latitude.	Longitude.	Pressure of Steam.	Coal Consumed.	Oil, Gallons.	Tallow, lbs.	Waste.	Mileage. Wheels.	Mileage. Ship.	Mileage. Slip.	Revolutions per Hour. Day.	Revolutions per Hour. Minute.	Miles per Ton.	Temperature. Sea.	Temperature. Feed.	Temperature. Engine Room.	Vacuum.	Remarks.
1864. Jan. 28	ft. in. 12 3	ft. in. 12 6	S.W.	Various	201	° ″ 51 47N	° ″ 7 2W	34	34	11	40	4	279	201	38·8	24,506	20	...	44	125	90	28	Jan. 28. Strong W. winds and thick cloudy weather; midnight, thick cloudy weather; ship pitching heavily, shipping much water.
„ 29	...	...	S.	S20, 8W	280	47 27N	9 47W	34	27	6	25	4	379	276	31·00	31,789	22	10·2	50	130	92	28	Jan. 29. Do. with heavy sea; ship pitching heavily; do. strong breeze.
„ 30	...	...	S.E.	S19, 11W	295	42 49N	12 4W	34	27	7	18	4	378	295	28·00	33,375	23	10·5	56	135	96	28½	Jan. 30. Fresh winds and cloudy, with heavy westerly swell.
„ 31	...	...	S.E.	S26, 4W	315	38 6N	15 6W	34	30	7	20	4	386	315	22·2	33,964	23·25	10·5	64	140	100	27½	Jan. 31. Do.
Feb. 1	...	...	S.S.E.	S15, 30W	298	33 19N	16 43W	34	31	7	20	4	391	300	23·5	34,391	23·5	10·00	68	140	102	27½	Feb. 1. Do. breeze and fine.
„ 2	...	...	S.S.E.	S18, 13W	293	28 44N	18 31W	33	30	7	20	4	379	300	21·00	33,435	23	10·00	70	140	106	27½	Feb. 2. Do. do. 10.50 a.m. observed Porto Santo Island; 3.30 p.m. off the Port of Madeira showed our number, distance 5 miles.
„ 3	...	...	Variable	S23, 57W	297	24 12N	20 46W	33	30	7	20	4	369	297	19·5	32,453	22·30	9·8	70	145	109	27½	Feb. 3. Do. winds and cloudy weather.
„ 4	...	...	Do.	S26, 49W	288	20 1N	23 3W	32	30	7	24	4	352	288	18·00	31,137	21·75	9·6	71	150	108	27	Feb. 4. Variable and fine.
„ 5	10 3	11 4	...	S31, 34W	219	At St.	Vincent	31	24	5	24	9	274	219	20·00	24,064	21	9·1	72	150	108	27	Feb. 5. Do. 2.30 observed St. Antonio ½ point on starboard bow, weather being hazy; laid to until daylight; 5.30 went on full speed; 6.45 anchored at St. Vincent; engines working well.
					2,486				263	64	211	41											Burning Scotch coal from first until arrival at St. Vincent.
									3	6	9												
									266	70	220	41											

R. MILLER, Chief Engineer.

	Coal consumed.		Oil, gallons.		Tallow, lbs.		Waste.
Stores on board	341	......	408	......	1,555	......	250
Consumed between Liverpool and St Vincent	70	......	220	......	41	......	—
Stores remaining at St. Vincent	—	......	338	......	1,335	......	209

HARDING'S PATENT IMPROVEMENTS IN ATMOSPHERIC RAILWAYS.

The object of this invention is chiefly to overcome the defects which have attached to the valvular portion of previously tried systems of atmospheric railways, or railways worked by the vacuum or pressure of air. The inventor uses a number of blocks or pieces of material converging towards each other, for the purpose of fitting into the trough or channel in the railway tube, and having also in relation to the longitudinal axis of the tube and the trough in which the blocks are fitted, angular faces or fitting, and bearing surfaces, a series of these blocks or pieces being jointed together forms the continuous flexible bar or valve. The trough being formed of V like shape in transverse section; and from the angular arrangement of bearing and fitting surfaces, between the blocks or pieces, greater perfection of working condition is ensured, so that the greater the atmospheric pressure, or the better the vacuum, the more perfect contact is obtained between the working parts of the apparatus. The accompanying wood cuts illustrate some of the methods of putting the invention into practice:—

FIG. 1.

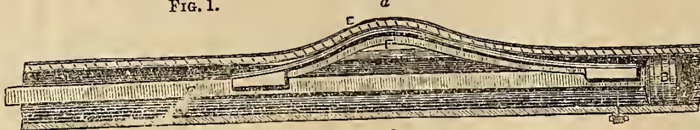


FIG 2.

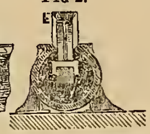


FIG. 3

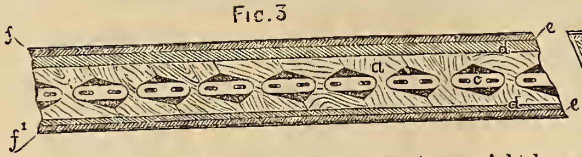


FIG. 4.

Fig. 1 being a longitudinal section of the tube of an atmospheric railway fitted with the piston, flexible bar, or valve, and curved lifting piece in accordance with the invention of the patentee; Fig. 2 is a cross section of Fig. 1, taken on the dotted line *a*, *b*, showing the tube, part of the flexible bar or valve fitting in the V shaped trough, the piston carriage, and the curved lifting piece.

A is the tube; B the piston; C piston rod; E the flexible bar or valve; F is the curved lifting piece.

In Figs. 3 and 4 the flexible bar or valve is shown separately and to an enlarged scale. The blocks *a*, composing the valve, are hinged together by means of fixed pins *b* and slotted links *c*, so as to counteract any strain, as by this plan the blocks slide upwards and downwards as the case might be, and the links allow the blocks free play. On the upper and lower surfaces of these blocks a band of india-rubber is laid, next to those are bands of leather, and on the outer upper surface is laid a metallic band or any other suitable material to protect the valve from rain or damp, and on the lower surface a thin band of steel is placed so as to allow it to ride easily upon the curved lifting piece F. Fig. 4 is a cross section of Fig. 3, in which a part of the slotted link *c* is shown.

The blocks may, however, be formed of metal or any other convenient material, and be solid or hollow. The bands shown in our illustrations might, when the metal blocks were employed, be replaced by a metallic band and leather strap on its under side, and screwed on to each of the blocks.

INSTITUTION OF MECHANICAL ENGINEERS.

DESCRIPTION OF NORTON'S V PUMP, AS MADE BY MESSRS. GEORGE FORRESTER AND Co., OF LIVERPOOL.

By Mr. J. J. BIRCKEL.

This contrivance, which is illustrated by the perspective view, Figure 1, and the accompanying diagrams, Figs. 2 and 3, may be generally described as a pump in which the barrel moves upon a stationary bucket, instead of the bucket moving in a stationary barrel, as in an ordinary pump; and it is termed V pump on account of the peculiar shape of both bucket and barrel, the reasons for adopting which will be explained in the sequel. The pump may of course be made with single or double-working barrel, as may be required by special circumstances, but in either case the whole contrivance, its construction and the mode of its working, are readily understood at a first glance. It is scarcely necessary to mention that it

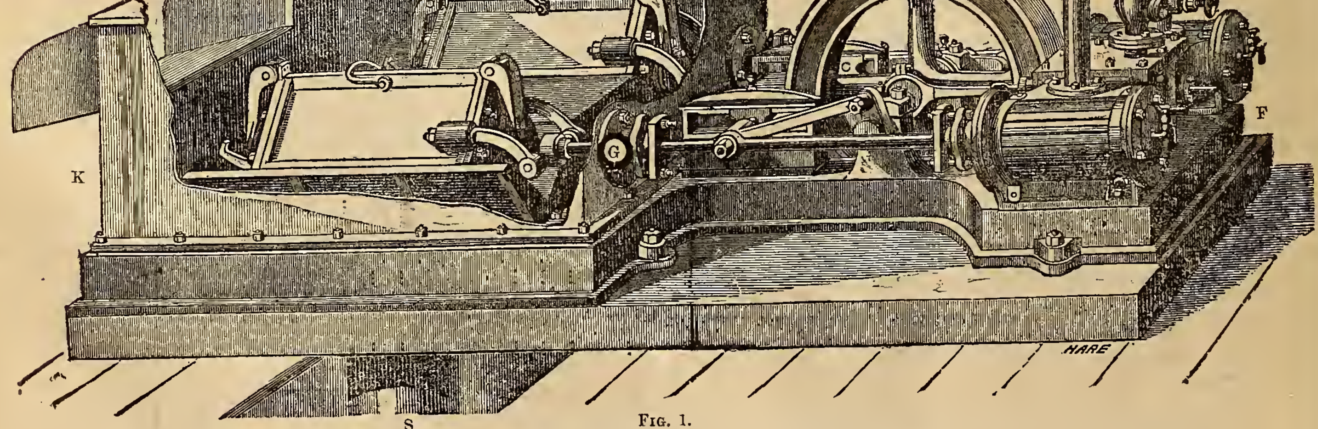


FIG. 1.

may be worked by gearing driven by hand or by power, or else directly by a steam cylinder, as in the one here illustrated; that mode of working it being probably the most profitable and the most convenient for the purposes for which it is best, and perhaps specially adapted, namely, those of drainage and of irrigation.

Fig. 2 shows a longitudinal section through one of the working barrels, and Fig. 3 shows a cross section through the two pump barrels. That portion which has been denominated the barrel is composed, first, of a lower half B, being a stationary bed, fixed upon and fitted water tight to a foundation plate, F; its working portions are planed true in their whole length, and the entire angle of these faces (which it will be seen assume the shape of a V) is 90 deg.; in the present instance the space between the two working barrels answers as a suction chamber Secondly, The working barrel is composed of a sliding part B_1, planed

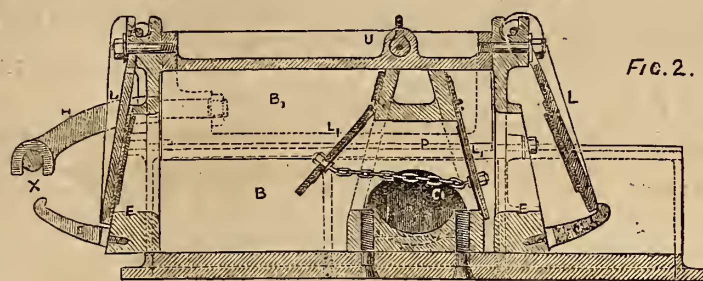


Fig. 2.

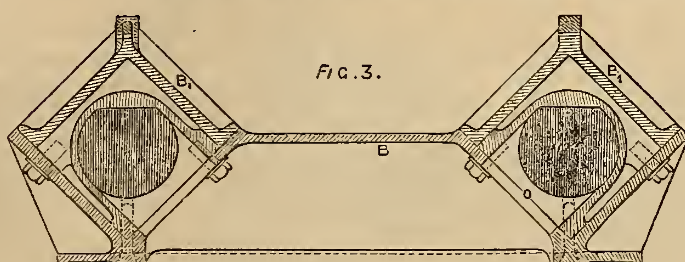


Fig. 3.

true also throughout its length inside, as well as upon its return flanges, which make a water tight fit with the faces of the lower half B. Two end pieces, or covers, E, Fig. 4, are bolted to the upper half B_1, by means of stud-

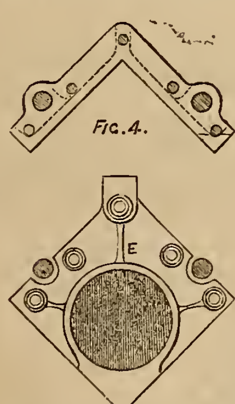


Fig. 4.

bolts; they fill the entire angular space of the working faces of the lower half B, to which they are fitted true and water tight, and by this means the barrel proper is completed; each of the end pieces, E, is provided with an aperture of sufficient area to discharge the water, and with a leather flap valve L, which are prevented from opening too much by means of the catches C. Two dragbolts, or hooks, H, are fixed into strong ears cast upon the upper half B_1 of the barrel, and are made to engage into a crosshead X, fixed upon the end of the piston-rod of the steam cylinder, by means of which motion is communicated to all the sliding parts of the barrel. A handle, U, is fixed to these also, for convenience of lifting them out of their places, and the drag hooks may be so constructed as to admit of this being done without disturbing the cross head X.

The bucket P is fitted tight to the lower half B of the barrel, to which it is firmly fixed by means of two strong screws, and it fits true also with the inner faces of the sliding portion B_1 of the barrel; it communicates with the suction chamber previously noticed by means of the aperture O, and opens at both ends into the barrel, each opening being provided with a leather flap valve L_1, which are each prevented from opening too wide by means of the chain C_1; the bucket is thus made to answer as a valve box.

When the sliding portion of the barrel is set in motion, a partial vacuum is created on that side of the bucket towards which the direction of motion takes place, and the atmospheric pressure causes the water to enter the barrel through the suction pipe S attached to the foundation plate F, while at the same time the water or the air which may be contained in the opposite end of the barrel is forced out through the aperture in the end piece E. In the return stroke the operation is reversed, and it will thus be perceived that by means of one valve box only the pump is rendered double acting.

A casing K is fitted tight upon the foundation plate F, and a complete cistern is thus formed into which the pumps deliver the water which has been raised; a continuous discharge then takes place through the overflow spout D, but the cistern is made of such height, and the spout so placed as to cause all the joints to remain constantly immersed in the water, thus making them perfectly air tight. The piston-rods of the steam cylinders, or their prolongations, work into the cistern K, through stuffing boxes G, fitted to that side of the cistern.

The arrangement of the steam cylinders and of the motion parts of the steam apparatus, which is seen in the perspective view, Fig. 1, is generally similar to that adopted in locomotive engines, and the whole mechanism resting on one bed-plate is thus self contained, consequently requires only a minimum outlay for foundations, and may be easily removed from one place to another.

The practical advantages possessed by this pump may be briefly stated as follows:—First. By adopting the V shape of the barrel, it was expected that the working faces would have a tendency to wear themselves true and tight instead of wearing themselves out of truth and leaky as is the case in common pumps, and practice has realised this expectation. Six or eight of these pumps were employed at the Main Drainage Works in London, where the water was heavily charged with sand so that they were actually grinding in sand; they continued, however, to do their work efficiently for upwards of six months without requiring replaning. This is, undoubtedly, a great advantage in countries where skilled mechanics are scarce, and where frequent repairs are not only expensive in themselves, but where the stoppages, which they occasion, are the source of still greater losses.

Secondly. Its construction allows ready access to all its parts, since the upper half, B_1, of the barrel can be removed at all times without trouble, being held down to its place by its own weight only when the pump is not actually working, and thus all repairs are rendered easy, and in so far less expensive.

Thirdly. It creates a far better vacuum, and, consequently, may be relied upon for a greater suction lift than pumps of the ordinary construction; thus, it is well-known that a common bucket pump, under ordinary circumstances, may not be trusted with a higher suction lift than 24ft., whereas it has been ascertained, in practice, that the V pump would always raise a column of water of from 28ft. to 30ft. this circum-

stance, however, is easily accounted for by the fact that the joints of the working barrel are constantly immersed under water; this is, in many cases, an advantage of the highest importance, as, for instance, when used for purposes of drainage or of irrigation of a temporary or intermittent character, where the expense of permanent foundations would be almost a dead loss.

It now remains to be shown whether the per centage of loss of useful work, by friction of its moving parts, is greater than in an ordinary bucket pump, the means for calculating which are furnished us by General Morin's experiments on friction. These experiments show that the resistance by friction of metal surfaces working under conditions similar to those of the sliding parts of this pump is 15 per cent. of the normal or perpendicular pressure which they sustain, and if W be made to represent the total vertical atmospheric load per lineal foot of the barrel, the normal pressure on the working faces per lineal foot will be

$$W\sqrt{2} = 1{,}41\ W$$

the resistance, therefore, at any point X of the stroke will be

$$0{,}15 \times 1{,}41\ W\ X = 0{,}21\ W\ X$$

and the work of friction during an infinitessimal part dx of the stroke will be

$$0{,}21\ W\ X\ d\ x$$

If L be now made to represent the whole stroke, the work of friction due to the atmospheric pressure during a complete stroke, will be found by integration.

$$\int_o^L 0{,}21\ W\ X\ d\ x = 0{,}21\ W\ \frac{L^2}{2} \quad . \ . \ . \ (1.)$$

To this must be added the work of friction due to the weight of the sliding portion of the barrel (which is a constant quantity); and when account is taken of the loss of weight occasioned by immersion in water of that part, if P be made to represent its total weight when not immersed this item is expressed as follows:—

$$0{,}21 \times 0{,}86\ P\ .\ L = 0{,}18\ P\ L \quad . \ . \ . \ . \ (2.)$$

The sum of the quantities (1) and (2) may be expressed thus:—

$$L\ (0{,}105\ W\ L + 0{,}18\ P) \quad . \ . \ . \ . \ . \ . \ (3.)$$

Assuming the pump, which we have illustrated, to raise a complete atmospheric column of water partly by suction and partly by the head in the cistern, the barrel being 11in. square and the stroke, 16in., the useful work performed in one stroke, is

$$11'' \times 11'' \times 15\text{lbs.} \times 1{\cdot}33\text{ft.} = 2{,}414 \text{ foot pounds,}$$

and the work absorbed by friction, the weight of the moving parts being about 350lbs., and the total load per foot run due to the column of water being

$$12'' \times 15{,}5'' \times 15\text{lbs.} = 2790\text{lbs.}$$

will be found thus,

$$1{,}33 \times (0{,}105 \times 2790 \times 1{,}33 + 0{,}18 \times 350) = 602 \text{ foot pounds}$$

or nearly 25 per cent. of the useful work.

In an ordinary cylindrical pump, with a leathered bucket, the coefficient of friction would be 0·37; and the work of friction in a pump of the same stroke and area of bucket, in which the useful work, therefore, would remain the same as in the case above calculated, assuming the bucket to have an effective bearing of 1½in. against the sides of the barrel, would be as follows:—

$$0{,}37 \times 1\tfrac{1}{2}'' \times 39'' \times 15\text{lbs.} \times 1{,}33\text{ft.} = 431{,}5 \text{ foot pouuds}$$

or nearly 18 per cent. of the useful work.

Calculation, therefore, shows an excess of loss by frictien of 7 per cent. iu the V pump as compared with the ordinary bucket pump, which, however, may be held to be fully compensated by the advantages previously enumerated. At the same time it should be stated that, inasmuch as the main item of loss by friction increases as the square of the stroke, this can be materially reduced by reducing the ratio of the side of the V to the stroke, which, in the pump under consideration, is as 1 ÷ 1·5 nearly, since the work of friction, and, consequently, the per centage of loss increases exactly as the square of this ratio; if, for instance, it was reduced to the value of 1 ÷ 1·3, the per centage of loss would at oncc fall from 25 to 19 per cent. of the useful work. Conversely, also, should the ratio of 1 ÷ 1·5 never be exceeded.

BLAKE'S STONE AND ORE CRUSHING MACHINE.

BY MR. LANCASTER.

The machiue shown by the annexed cuts is designed to break stoues into small fragments, to be used for road making, railroad ballasting, concrete, or other purposes, aud to crush ores or minerals of any kiud, likewise particularly adapted to break flints raw or calcined, for crockery ware. It is simple and compact, and being complete in itself, requires no extraneous support or fixtures.

Description.—Fig. 1 is a perspective view of the machine entire. The frame A, which receives and supports all the other parts, is cast in one piece, with feet to stand upon the floor or on timbers. These feet are provided with holes for bolts by which it may be fastened down if desired, but this is unnecessary, as its own weight gives it all the stability it requires. B B are fly wheels, on a shaft which has its bearings on the frame, and which, between these bearings, is formed into a short crank. C is a pulley on the same shaft, to receive a belt from a steam engine or other power.

Fig. 2 shows a side view or elevation of the other parts of the machine in place, as they would be presented to view by removing oue side of the frame. The parts of this figure which are shaded by diagonal lines, are sections of those

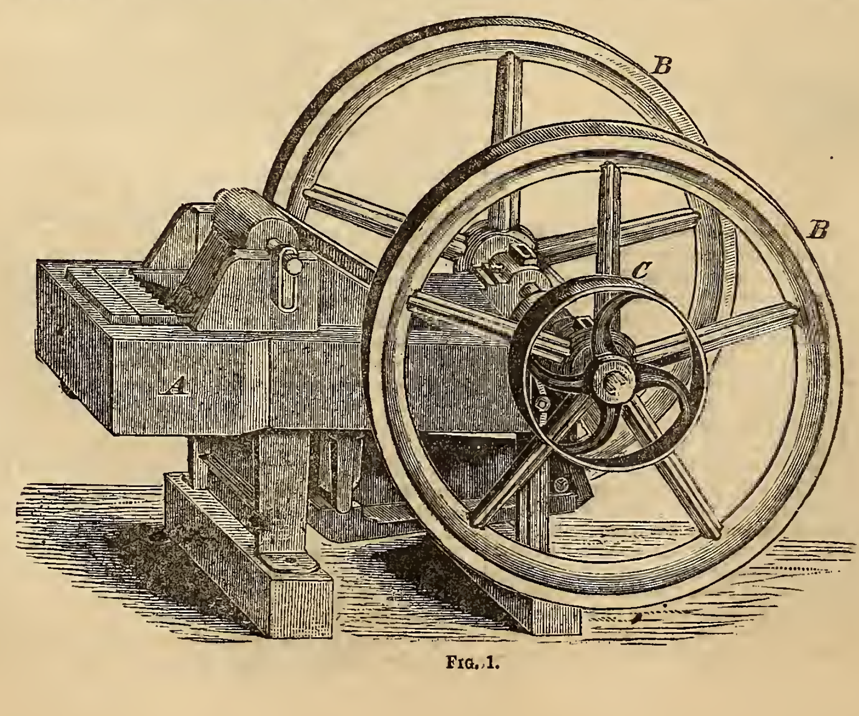


FIG. 1.

parts of the frame which connect its two sides, and which are supposed to be cut asunder, in order to remove one side, and present the other parts to view. The dotted circle D is a section of the fly wheel shaft, and the circle E is a section of the crank. F is a pitman or connecting rod, which connects the crank with the lever G. This lever has its fulcrum on the frame at H. A vertical piece I stands upon the lever, against the top of which piece the toggles J J have their bearings, forming an elbow or toggle joint. K is the fixed jaw against which the stones are crushed. This is bedded in zinc against the end of the frame, and held back to its place by cheeks L, that fit in recesses in the interior of the frame on each side. M is the moveable jaw. This is supported by the round bar of iron N which passes freely through it and forms the pivot upon which it vibrates. O is a spring of india rubber which is distended during the forward movement of the jaw and aids its return ; both jaws are fluted vertically, which gives the bite a wedge-like lateral action.

Every revolution of the crank causes the lower end of the moveable jaw to advance towards the fixed jaw about $\frac{3}{8}$ of an inch and return. Hence, if a stone be dropped in between the convergent faces of the jaws, it will be broken by the next succeeding bite; the resulting fragments will then fall lower down and be broken again, and so on until they are made small enough to pass out at the bottom. The readiness with which the hardest stones yield at once to the influence of this gentle and quiet movement and melt down into small fragments, surprises and astonishes every one who witnesses the operation of the machine.

It will be seen that the distance between the jaws at the bottom limits the size of the fragments. This distance, and consequently the size of the fragments may be regulated at pleasure. A variation to the extent of $\frac{5}{8}$ of an inch may be made by turning the screw-nut P, which raises and lowers the wedge Q, and moves the toggle-block R, forward or back. Further variations may be made by substituting for the toggles J J, or either of them, others that are longer or shorter, extra toggles of different lengths being furnished for this purpose.

Mr. Lancaster stated that in the machine used at the Kirkless Hall Iron Works, for breaking the lime stone to serve as flux in melting the ore, the jaws were 20in. by 9in., and the quantity of stone broken was from 100 to 120 tons per day of 10 hours, at a cost of 3*d*. per ton; the original size of the blocks of stone is on an average of such weight that a man just can lift it into the hopper from which the machine is fed, and the average size of the stone delivered is about equal to a cube of $1\frac{1}{2}$in. square. The cost of breaking the stone, as above quoted, includes the attendance, the power absorbed, and the maintenance of the machine. The cost of breaking the stone by hand labour, Mr. Lancaster stated, was, at his establishment, 7*d*. per ton, showing a saving of nearly 60 per cent. by the use of this machine.

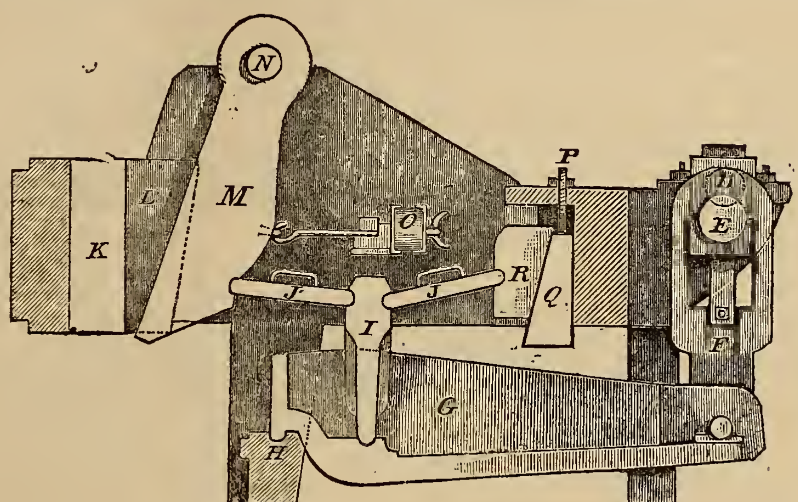


FIG. 2.

The product of these machines per hour, however, will vary considerably with the character of the stone broken. Stone that is granular in its fracture, like granite and most kinds of sand-stone will pass through more rapidly than that which is more compact in its structure. The kind of stone being the same, the product per hour will be in proportion to the width of the jaws, the distance between them at the bottom and the speed. The proper speed is about 200 revolutions per minute, and to make good road metal from hard compact stone, the jaws should be set from $1\frac{1}{4}$in. to $1\frac{1}{2}$in. apart at the bottom. For softer and for granular stones they may be set wider.

The following table shows the several sizes of machines for which the makers, Messrs. Marsden, of Leeds, have patterns ; the product per hour of each size, of fine road metal from the hardest materials when run with a speed of 200,—the power required to perform this duty,—the whole weight of each size, and the weight of the heaviest piece when separated for transportation.

Size.	Product per hour.	Power required.	Total Weight.	Weight of Frame.	Net Price.
10 by 7	3 cubic yards	3 horse.	7,000lbs.	2,600lbs.	£140
15 by 7	$4\frac{1}{2}$ „	4 „	9,500 „	3,900 „	£180
20 by 7	6 „	6 „	14,000 „	6,600 „	£240
20 by 9	6 „	5 „	14,500 „	7,000 „	

The whole length of the machines to the back-side of the wheels, is from 8ft. to $8\frac{1}{2}$ft. height to top of wheels, 5ft.; width, from 4ft. to 5ft.

The machines may be driven by any power less than that given in the table yielding a product per hour smaller in the same proportion.

It will be observed that the product named in this table corresponds with that given by Mr. Lancaster, assuming that $16\frac{1}{2}$ cubic feet of broken stone represent a ton weight.

The motion of the jaw M is $\frac{3}{8}$in. in all the machines hitherto made, and in that used by Mr. Lancaster the driving pulley is 3ft. diameter, and 8in. broad. This at the rate of 200 revolutions, and with a power of 5 horse actually consumed, would give a tractile force applied by the driving belt at the circumference of the pulley of

$$\frac{33{,}000 \times 5}{3 \times \pi \times 200} = 87\tfrac{1}{2}\text{lbs.}$$

Which tractile force moves through a space of 1,884ft., whilst the jaw *works* through a space of $\frac{3}{8}$in., the work transmitted by the belt during the return stroke of the jaw being stored up in the fly wheels B B, and actually consumed during the working period of the jaw ; the purchase, therefore, is as

$$3 \div 3 \times \pi \times 200 \times 8 \times 12 = 1 \div 60288,$$

which gives a theoretical mean pressure of $235\frac{1}{2}$ tons at the lowest point of the jaws. Assuming, however, that there is a loss of 10 per cent. through friction in the several bearings, there remains a mean actual pressure of 212 tons at the lowest point of the jaws.

In the discussion which followed the reading of this paper, unqualified praise was bestowed upon this machine both on the ground of the simplicity of its construction, and on account of the singularly practical results derived from its use in the various industries or engineering operations to which it has been applied.

COTTON CULTIVATION IN FRANCE.—We understand that the trial of the culture of cotton in the district of Arles has resulted very favourably. Among the bolls of cotton gathered some have the long staple and others the short. The essay, made on a small scale and in the open air, has perfectly succeeded. At the end of November the plants were yet covered with a great number of bolls which continued to ripen, though very slowly. Those gathered in August, September, and October were very well matured.

INSTITUTION OF CIVIL ENGINEERS.

ON THE CLOSING OF RECLAMATION BANKS.

By Mr. Heppel.

In the discussion upon Mr. Heppel's paper, it was remarked that, at the mouth of the River Thames, on the Essex coast, there were two large foreshores, which had frequently been the subject of projects for reclamation. These were the Maplin Sands and the Dengie Flats. The latter comprised an area of about 7,000 acres, entirely covered with mud, which had gradually accumulated to a depth at present of from 6ft. to 8ft. and 9ft., and the surface of which was in no place more than 6ft. under high water of spring tides. The inquiry instituted by the author had reference to the intended enclosure, then about to be commenced, of the Dengie Flats, or of a portion of them; but the investigation was applicable in all similar undertakings, and hence, it was believed, would be found to possess general interest and value; for it was a ready practical method of determining the width of opening which should be provided for any given area. In the case alluded to, it was decided not to attempt the enclosure of the entire area at one operation, but to divide it into ten or twelve sections, and to leave four or five outlets, each from 100ft. to 200ft. in width, probably at the most depressed parts of the foreshore and together capable of draining the entire area, at every ebb tide, and to effect the final closing at neap tides, when there was the least head of water to contend with.

It was thought that the practical question for engineers to consider was, how to close the openings, or to stop up breaches in the banks when they occurred. The method adopted in those countries, where breaches were more frequent than in Great Britain, was gradually to shallow the opening, by bringing up horizontal layers of suitable materials, such as brushwood and stones, or, what was by some deemed preferable, clay puddle, and eventually to pump out the water, instead of stopping the opening vertically, by more or less rapid means. By raising the bottom, the velocity through the opening was diminished, whereas in the other case, as the work proceeded and the width of the opening was diminished, the velocity of the water, and consequently the scour and the danger, were increased.

It was observed that the most expensive way of acquiring land was attempting to reclaim it from the sea; and that, contrary to the apparent belief of the author, the quantity of water flowing in and out of an opening was so exceedingly variable, as to render its expression in an equation almost impossible. It was thought that enclosure works of less than 800 acres, the area usual in Holstein, would not pay commercially, and that, having regard to economy, from 1,200 acres to 1,500 acres was the utmost extent that ought to be comprised in one operation, as the difficulty of finally enclosing such an area became almost insurmountable. Nor should the surface of the area to be reclaimed be more than from 3ft. to 4ft. under the level of high water; though in the River Tay it was stated that the reclamation embankments were commenced when the mud was about half-tide level, or 9ft. under high water. There were large tracts of enclosed land on the banks of the River Thames, at a level of about 7ft. under high water, and in the fen districts of England, particularly in the counties of Bedfordshire and Lincolnshire, some of the land was from 11ft. to 14ft. under high water mark. It was to be regretted that there were no authentic records of the manner in which these vast reclamations had been effected. There was, however, evidence to show that the works had been executed in detail—from 1,000 acres to 1,200 acres being probably taken in at one time. With regard to the method to be adopted in closing the banks, or breaches, although driving piles and dropping planks between them might be available in one particular situation, yet in most cases it was an expedient of all others likely to be the most disastrous. In Holland, when the proper width of opening, due to the area of land to be enclosed, had been ascertained, the work was brought up, stage by stage, with the best materials of the district, protected by stonework and fascines, and carried on by a population accustomed to the work. In that country there was no difficulty in effecting enclosures, and of protecting the banks afterwards from storms which arose before the works were consolidated, or the herbage had grown to divert the effect of heavy seas.

It was stated that in Schleswig, Holstein, and Friesland, many of the reclamations were effected in small "polders," not exceeding, say from 20 acres to 50 acres each. With respect to the fen districts of England, it was contended that records certainly existed, for Wells's "History of the Fens" contained an account of the original grants and privileges and the conditions imposed upon the early adventurers. To this it was replied, that Wells's treatise dealt purely with legal matters. No doubt these reclamations had been made in detail, the precise area being dependent upon local circumstances. Originally Dutch labour was imported, but this kind of work having been continually in progress over a long period of time, there was now a class of persons in the district who had been bred to and were accustomed to the work.

It was mentioned that after two attempts to close Dagenham breach, on the Thames, by Captain Perry, had been unsuccessful, it was eventually accomplished, at great cost, by driving two rows of dovetailed sheeting piles, about 40ft. apart, the heads being about one foot above low water; then making up with hard stuff between them, and gradually raising the embankment. A large sluice was formed on the higher ground, which could be easily closed, and the water was led to it by a cut.

The method of graphic integration, adopted by the author, for calculating the pressures which would come upon the breach, seemed, to some extent, to get rid of the mathematical difficulties of the case. The method of tentatively ascertaining the laws which regulated the rise and fall of the water, was a simple application of the integral calculus to the mechanical formation of the curve, from another curve, of which the mathematical form was not known in algebraic form, as the data given did not come easily into the expression of mathematical formulæ.

In replying upon the discussion, it was remarked that the process described in the paper was stated to be tentative only. It was an attempt to elucidate a question incapable of being expressed by formulæ; in fact, it was a mode of treating geometrically that which could not be dealt with analytically. The real object of the paper was to show that with a given rise of tide, width of opening, and area to be reclaimed, certain velocities would result, without entering into the mode of construction, which would be dependent upon many contingent circumstances, and must be decided by the engineer, after a careful review and consideration of the peculiarities of the work in hand. In the particular case which had been referred to, the land was protected from the full effects of the sea by a long foreshore, which would diminish the effects of the forces to which the works might be exposed.

ON THE RESISTANCES TO BODIES PASSING THROUGH WATER.

By Mr. G. H. Phipps, M. Inst. C.E.

These resistances comprised the Plus Resistance, or that concerned in moving out of the way the fluid in advance of the body; the Minus Resistance, or the diminution of the statical pressure behind any body when put into a state of motion in a fluid; and the Frictional Resistance of the surface of the body in contact with the water.

The Plus Resistance of a plane surface one foot area, moving at right angles to itself in sea water, was considered to be

$$R = \frac{64{\cdot}2 \times v^2}{2\,g},$$

and the Minus Resistance was one-half the Plus Resistance.

For planes moving in directions not at right angles to themselves, the theoretical resistances were, for the Plus Pressure—

$$S = \frac{a}{r^2} \text{ and } R = \frac{S\ 64{\cdot}2\ v^2}{2\,g},$$

the Minus Pressure being one-half the above; where R was the resistance of the inclined plane; a, the area of the projection of the inclined plane upon a plane at right angles to the direction of motion; r, the ratio of the areas of the projected and the inclined planes; and S, the area of a square-acting plane of equivalent resistance with the inclined plane.

But, besides these theoretical resistances, the experiments of Beaufoy showed, that when the inclined planes were of moderate length only, the Plus Resistance was considerably in excess of the above; so that when the slant lengths of the planes were to their bases in the proportion of

2 to 1, 3 to 1, 4 to 1, and 6 to 1,

the actual resistances exceeded the theoretical, as

1·1 to 1, 1·98 to 1, 3·24 to 1, and 6·95 to 1.

The author proposed a method of approximating to these additional resistances, by adding the constant fraction of $\frac{1}{7}$th of a square foot, for every foot in depth of the plane, to the quantity S previously determined, which empirical method he found to agree nearly with the results of Beaufoy's experiments.

The resistances of curved surfaces, such as the bows of ships, were adverted to, the method of treating them being to divide the depth of immersion into several horizontal layers, and then again into a number of straight portions, and to deal with each portion as a separate detached plane, according to the preceding rules.

The question of friction was then considered. The experiments of Beaufoy were referred to, giving 0·339lb. per square foot as the co-efficient of friction for a planed and painted surface of fir, moved through the water at 10ft. per second, the law of increase being nearly as the squares of the velocities, viz., the 1·949 power. The author was, however, of opinion that a surer practical guide for determining the co-efficient of friction would be, by considering all the data and circumstances of a steamship of modern construction, moving through the water at any given speed. The actual indicated horse-power of the engines being given, the slip of the paddles being known, and the friction and other losses of power approximated to, it was clear that the portion of the power necessary to overcome the resistance of the vessel might be easily deduced. By determining approximately, by the preceding rules, the amounts of the Plus, the Minus, and the Additional Head resistances, and deducting them from the total resistance, the remainder would be the resistance due to the friction of the surface. By this process, and taking, as an example, the iron steamship *Leinster*, when perfectly clean, and going on her trial trip 30ft. per second in sea water, her immersed surface being 13,000 square feet, the co-efficient of friction came out at 4·34lbs. per square foot.* Beaufoy's co-efficient of 0·339lb. per square foot at 10ft. per second, would, according to the square of the velocities, amount to 3·051lbs. at 30ft. per second. The difference between this amount and the above 4·34lbs., might be accounted for by a difference in the degree of roughness of the furnaces.

Other methods for the determination of the co-efficient of friction were then discussed. One, derived from the known friction of water running along pipes, or water courses, was shown to be considerably in excess of the truth. It was founded upon the observed fact, that at a velocity of 15ft. per second, the friction of fresh water on the interior of a pipe was 25oz.† per square foot. Applying

* Since the paper was written, the accuracy of the above co-efficient had been confirmed, very nearly, by an examination of another vessel, the *Atrato*, of different type from the *Leinster*, the calculations of which were given in an Appendix.

† For sea water this quantity must be increased as the specific gravity, or as 62·5 to 64·2.

this to the ship *Leinster*, and increasing the friction as the squares of the velocities up to 30ft. per second, the above friction would become 100oz., or 6¼lbs. per square foot, which, acting upon 13,000 square feet of surface, would absorb, at the above speed, no less than 4,395 horse-power, whilst the total available power of the engines (after deducting from the indicated 4,751 horse-power $\frac{1}{10}$th for friction, working air-pumps, and other losses, and $\frac{1}{5}$th of the remainder for the observed slip), was only 3,421 horse-power; thus showing an excess of resistance equal to 974 horse-power, without allowing any power to overcome the other resistances. The assumption of 25oz. being the proper measure of the friction per square foot, at a velocity of 15ft. per second, upon the clean surface of an iron ship, seemed to have arisen from the opinion, very generally entertained, that there was no difference in the amonnt of frictiou in pipes and watercourses, whether iuternally smooth like glass, or moderately rough like cast iron, and that the surfaces of ships were subject to the same action. The comparatively recent experiments, in France, of the late M. Henry Darcy were in opposition to the above view, and showed that the condition as to roughness of the interior of a pipe modified the friction considerably. Thus, with three different conditions of surface, the co-efficients were:—

A. Iron plate covered with bitumen made very smooth	0·000432
B. New cast iron..	0·000584
C. Cast iron covered with deposits	0·001167

The friction was, therefore, nearly as 1, 1½, and 3.

As there appeared no reason to doubt the correctness of M. Darcy's experiments, even in pipes, the notion of the friction being uninfluenced by the state of roughness of the interior could no longer be entertained. The 25oz., previously mentioned as the measure of friction per square foot for the interior of pipes and watercourses, could not, therefore, be regarded as a constant quantity, applicable to all kinds of surfaces; but from the author's calculations, it appeared to come in immediately between the co-efficieuts of the surfaces B and C, given in the above scale; as at 15ft. per second,

A	would give	13⅓oz.	per square	foot
B	„	20	„	„
and C	„	40	„	„

Besides, there was another cause for an excess of friction in pipes and watercourses, over that upon ships, even when the surfaces were equally smooth. It arose from the circumstance, that where the velocity of the water in a pipe, or open watercourse, was spoken of, the meaning was, its average velocity; whilst the the velocity of a vessel through still water meant what the words implied, namely, the relation of the vessel's motion to the fluid at rest. If the case were taken of a watercourse of such width, that the friction of the bottom only need be considered, with an average velocity of flow of 15ft. per second, the friction upon the bottom would be equal to 25oz. per square foot; but according to the rules generally used, an average velocity of 15ft. per second corresponded to a surface velocity of 16·66ft. per second, which was the velocity with which a vessel should pass through still water, to give an equal friction upon its sides. According to Beaufoy, the velocity of 16·66ft. per secoud, wonld produce a friction of ·932lb. or 14·91oz., where 15ft. would only give 12·2oz. The difference between the 14·91oz. and 25oz. (equal to 10·09oz.) must, therefore, be set down to the different degree of roughness of the surfaces in the watercourse and the vessel.

Taking then 4·34lbs. as the friction per square foot of a new iron ship, moving through the water at a speed of 30ft. per second, it would be found that this was eqnal to the $\frac{1}{207 \cdot 06}$ part of the plus resistance of a plane 1ft. square, moving through the water at right angles to itself at the above velocity. Also, as the resistance of both planes increased according to the same law of the square of the velocities, the ratio of 1 to 207·06 would subsist at all velocities. The ratio was as $\frac{64 \cdot 2 v^2}{2g}$ to 4·34lbs. $= \frac{1}{207 \cdot 06}$ Calling the ratio r, and the whole frictional surface in square feet s, and S, as before, the area of a square-acting plane of equivalent resistance, then

$$S = s \div r = s \div 207 \cdot 06$$

As an example of the application of the previous deductions, the performance of the steamship *Leinster*, ou her trial trip, wheu going through sea-water at a speed of 30 feet per second was referred to.

In this case—

m, the area of the immersed midship sectiou was	336 sq. feet.
d, the draught of water	13 feet.
r, the reduced ratio of the slant length of the bow to the projection..	10 to 1.
r', the same for the stern..	10 to 1.
r'', the ratio of 1 square foot of square-acting plaue, to 1 square foot of frictional surface	207·06 to 1.
v, the velocity in feet per second....................................	30
w, the weight of a cubic foot of sea water..............................	64·2lbs.
f, the area of the frictional surface....................................	13,000 sq. feet.

Calling P, the Plus, or head resistance; M, the Minus, or stern resistance A, the Additional head resistance; F, the Frictional, or surface resistance; S, the area of a square-acting plane having an equal resistance with each of the above; and R, the total resistance;

Then,

$$P = \frac{m}{r^2} = S = \frac{336}{100} = 3 \cdot 36 \text{ sq. ft.}$$

$$M = \tfrac{1}{2}\,\frac{m}{r^2} = S = \tfrac{1}{2}\,\frac{336}{100} = 1 \cdot 68 \text{ sq. ft.}$$

$$A = \frac{13}{7} = S = \qquad 1 \cdot 86 \quad „$$

$$F = \frac{13{,}000}{207 \cdot 06} = S = \qquad 62 \cdot 78 \quad „$$

$$S = \qquad 69 \cdot 68 \quad „$$

$$R = 69 \cdot 68 \times \frac{64 \cdot 2\, v^2}{2\,g} = 69 \cdot 68 \times 900 = 62{,}712 \text{ lbs.}$$

H (Realised Power) = 62,712 lbs. × 30 ÷ 550 = 3420·66 H.P.

H′ (Gross Power) including the slip and other losses = 3420·66 × $\frac{100}{72}$ = 4,751 H.P.

Thus, by ascertaining the value of S for any vessel, which was eutirely indepeudeut of velocity, it would be easy to determine the power necessary to propel it at any required speed, or the speed beiug given, to find the corresponding power.

$$\text{Generally } H = V\,S\,\frac{64 \cdot 2\, V^2}{2\,g} \div 550 \qquad (1.)$$

Or, because for sea water 64·2 was very nearly equal to 2 g,

$$H = \frac{V^3\,S}{550} \qquad (2.)$$

When the slip and other losses were in the same proportion as in the *Leinster*.

$$* \; H' = H\,\frac{100}{72} \qquad (3.)$$

When the gross power was given, and the velocity was required:

$$\dagger \; V = \left(\frac{\frac{72}{100}\,H' \times 550}{S\,\frac{64 \cdot 2}{2\,g}} \right)^{\frac{1}{3}} \ldots\ldots\ldots\ldots\ldots\ldots \; (4.)$$

The author then proceeded to examine the question of the iuflueuce of form in reducing the resistauce of vessels.

It was argued that, in vessels of similar type to the *Leinster*, where $\frac{9}{10}$ths of the whole resistance was due to friction, and only $\frac{1}{10}$th to considerations involving the question of "form," no miuor modifications of the latter could have much effect in diminishing the total resistance. The case of other vessels of different type, more bluff in the bows and not so fine in the run, was adverted to, and a particular instance was discussed, where the inertial resistance was supposed to be equal to $\frac{1}{5}$th of the total resistauce, and the slant length of the bows to the base to be as 6 to 1. If such a vessel were altered, so as to make the above proportion 8½ to 1, the improvement would ouly diminish the total resistance by $\frac{1}{10}$th.

In opposition, however, to this view, the author referred to several ships, the particulars of which werc given in the discussion upon Mr. Armstroug's Paper on "High Speed Steam Navigation." These vessels were the *Rifleman*, the *Teazer*, the *Dwarf*, the *Magnet*, the *Flying Fish*, and two vessels by Mr. Scott Russell. By moderate improvements in the bows and run of the above vessels, the resistance was dimiuished to degrees varying from ½ to $\frac{1}{9}$th of the whole, a considerably greater improvement than could be accounted for upon the principles of calculation in the paper.

Without attemptiug to solve the difficulty, the author threw out, as a suggestion for examination, whether, as nearly all the above vessels were propelled hy screws, the improvements noted might not be referable to an improved action in the propelling instrument, brought about by an alteration in the hulls of the vessels, and the question suggested itself, whether if the resistances of the vessels in question could have been ascertained by means of a dynamometer applied to a towing rope, the improvement would have been so great, as when shown by the diminished power of the eugines?

LONDON ASSOCIATION OF FOREMEN ENGINEERS.

The eleventh anniversary of the formation of this society was celebrated by a dinner at Radley's Hotel, New Bridge-street, Blackfriars, on Saturday, the 27th February. Henry Grissell, Esq., C.E., presided on the occasion, supported by Mr. Telford Field (Maudslay, Sons, and Field); Mr. E. J. Reed; Mr. Joseph Newton, President of the Association; Mr. W. Smith, C.E.; Mr. Edwards; Captains Blakely and M'Gregor; the Hon. Mr. Duncan; Mr. H. J. Cohen; Mr. Rishton; Mr. Simpson, of Pimlico; Messrs. Winchester, Graveley, and others.

In reply to the toasts given by the Chairman, Captain Blakely said he was not now directly connected with the military service, though indirectly, as a manufacturer of weapons of warfare, he was; and he felt certain that, whatever chauges engineering science might effect in conducting hostilities, the British soldier would ever be found equal to his work. The gallant gentleman further observed that improvements in the materials and the construction of guns, in their mode of manufactnre, and in the plans of working them, were sure to be made, and it was the province of the audience he then addressed to devote their attention to such subjects. It was in the interests of humanity that the art of war should be both scientifically and practically understood by his fellow-countrymen, because the lesson thus taught would be an effectual barrier to the aggressive propensities of other natious.

* If for fresh water H′ × 0·97 = H P.

† If for fresh water V ÷ 0·99 = velocity.

Mr. E. J. Reed, in replying to the Navy, took the opportunity of entering into some details as to the difficulties by which he was surrounded, and complained of the severe, and in some cases the ignorant, criticisms to which he was subjected. His duties were onerous enough in themselves, as the eyes of the whole world were fixed upon the alterations which were being made in the British Navy, and it was essential that he should be supported at home, or, at all events, not attacked unfairly. He had, however, hitherto devoted his entire energy to the task which the Government had entrusted to him, and he intended to proceed in the same way in the future. Mr. Reed then spoke of the union which now existed between the engineer and the shipbuilder, and the necessity there was for their working together in harmony. He also referred to the construction of steam rams, and concluded by thanking the assembled foremen for the enthusiastic way in which they had received the toast to which he had been invited to respond.

The Secretary of the Association, Mr. John Jones, then proceeded to read his annual report, which appeared to be on the whole of a highly satisfactory nature. The sum at present invested on behalf of the society in the 3 per cent. consols amounted to £347 17*s.* 9*d.* The number of ordinary members of the association was 75, and that of the honorary members, 28, or, in all, 103.

The Chairman said that they had now arrived at that juncture when it was incumbent upon him to propose the toast of the evening. In doing so he must take a retrospective glance over the last dozen years. When the society over which he had on that evening great pleasure in presiding was first established, namely in the year 1852, the labour market in this country, so far as mechanical trades were concerned, was much disturbed by strikes, and he must confess that he looked with some distrust upon anything like a combination of foremen engineers. That feeling he knew was shared in by other employers at the time, and, in fact, was not entirely dissipated yet. For himself, he must say, however, that he had no longer any such sentiment. He had taken care to inquire into the nature of the proceedings of the Associated Foremen at their monthly meetings, and he saw nothing in those proceedings to object to, but, rather, much to approve of. Several of his own foremen were at that moment members of the society, and one who was deceased (Mr. George Sheaves) might almost be said to have been its originator. Mr. Grissell then entered into a rather lengthy dissertation upon the relative positions of employers and employed, and the duties of each toward the other. In conclusion, the Chairman remarked that, in order to carry out fully the rules of the Association of Foremen Engineers, it ought to have a much larger balance in the bank than the Secretary's report demonstrated to be in existence. He could not see, for example, how the system of paying superannuities to decayed members was to be effected under present circumstances. He thought it also desirable that the benevolent and the scientific sections of the institution should, so far as the funds were concerned, be separate and distinct from each other. As a proof of his friendship for the Association, and his desire for its future well-being, he should hand in his name as an honorary member, and would promise to place £50 to the account of the society, provided nine other employers would do likewise. The Chairman then formally proposed the toast of "Prosperity to the Association of Foremen Engineers, coupled with the name of Mr. Newton, its President."

Mr. Newton, who was warmly received, afterwards spoke at some length of the aims and objects of the society, and proved that it was worthy the countenance and support of engineering employers, both in a material and in a moral sense. He gave finally, as a toast, "The Health of the Employers, and success to the Engineering Trade," and in conjuction with it mentioned the name of Mr. Telford Field.

Mr. Field replied on behalf of the employers, and expressed his confidence in the value of this association. He said he would follow the example led by the Chairman, and, in addition to joining as an honorary member, would promise for the firm to which he belonged a donation of £50 to the benevolent fund.

Mr. W. Smith, C.E., also, in replying on behalf of the employers, expressed a hope that the £500 spoken of by the Chairman would soon be raised, and promising, if the society would permit him, to make the amount, when raised, 500 guineas, by a donation of £25.

The usual toasts were given and responded to, and the meeting was brought to a close shortly before twelve o'clock.

THE ROYAL SOCIETY.

EXPERIMENTS TO DETERMINE THE EFFECTS OF IMPACT, VIBRATORY ACTION, AND A LONG-CONTINUED CHANGE OF LOAD ON WROUGHT-IRON GIRDERS.

By WILLIAM FAIRBAIRN, LL.D., F.R.S.

The following is an abstract of Mr. Fairbairn's communication. The author observed that the experiments which were undertaken, nearly twenty years ago, to determine the strength and form of the Tubular Bridges which now span the Conway and Menai Straits, led to the adoption of certain forms of girder, such as the tubular, the plate, and the lattice girder, and other forms founded on the principle developed in the construction of these bridges. It was at first designed that the ultimate strength of these structures should be six times the heaviest load that could ever be laid upon them, after deducting half the weight of the tubes. This was considered a fair margin of strength; but subsequent considerations, such as generally attend a new principle of construction with an untried material, showed the expediency of increasing it; and instead of the ultimate strength being six times, it was in some instances increased to eight times the weight of the greatest load.

The proved stability of these bridges gave increased confidence to the engineer and the public, and for several years the resistance of six times the heaviest load was considered an amply sufficient provision of strength.

But a general demand soon arose for wrought-iron bridges, and many were made without due regard to first principles, or to the law of proportion necessary to be observed in the sectional areas of the top and bottom flanges, so clearly and satisfactorily shown in the early experiments. The result of this was the construction of weak bridges, many of them so ill-proportioned in the distribution of the material as to be almost at the point of rupture with little more than double the permanent load. The evil was enhanced by the erroneous system of contractors tendering by weight, which led to the introduction of bad iron, and in many cases equally bad workmanship.

The deficiencies and break-downs which in this way followed the first successful application of wrought iron to the building of bridges led to doubts and fears as to their security. Ultimately it was decided by the Board of Trade that in wrought iron bridges the strain with the heaviest load should not exceed 5 tons per square inch; but on what principle this standard was established does not appear.

The requirement of 5 tons per square inch did not appear sufficiently definite to secure in all cases the best form of construction. It is well known that the powers of resistance to strain in wrought iron are widely different, according as we apply a force of tension or compression; it is even possible so to disproportion the top and bottom areas of a wrought iron girder calculated to support six times the rolling load, as to cause it to yield with little more than half the ultimate strain or 10 tons on the square inch. For example, in wrought iron girders with solid tops it requires the sectional area in the top to be nearly double that of the bottom to equalize the two forces of tension and compression; and unless these proportions are strictly adhered to in the construction, the 5-ton strain per square inch is a fallacy which may lead to dangerous errors. Again, it was ascertained from direct experiment that double the quantity of material in the top of a wrought iron girder was not the most effective form for resisting compression. On the contrary, it was found that little more than half the sectional area of the top, when converted into rectangular cells, was equivalent in its powers of resistance to double the area when formed of a solid top plate. This discovery was of great value in the construction of tubes and girders of wide span, as the weight of the structure itself (which increases as the cubes, and the strength only as the squares) forms an important part of the load to which it is subjected. On this question it is evident that the requirements of a strain not exceeding 5 tons per square inch cannot be applied in both cases, and the rule is therefore ambiguous as regards its application to different forms of structure. In that rule, moreover, there is nothing said about the dead weight of the bridge; and we are not informed whether the breaking weight is to be so many times the applied weight plus the multiple of the load, or, in other words, whether it includes or is exclusive of the weight of the bridge itself.

These data are wanting in the railway instructions; and until some fixed principle of construction is determined upon, accompanied by a standard measure of strength, it is in vain to look for any satisfactory results in the erection of road and railway bridges composed entirely of wrought iron.

The author was led to inquire into this subject with more than ordinary care, not only on account of the imperfect state of our knowledge, but from the want of definite instructions. In the following experimental researches he has endeavoured to ascertain the extent to which a bridge or girder of wrought iron may be strained without injury to its ultimate powers of resistance, or the exact amount of load to which a bridge may be subjected without endangering its safety—in other words, to determine the fractional strain of its estimated powers of resistance.

To arrive at correct results and to imitate as nearly as possible the strain to which bridges are subjected by the passage of heavy trains, the apparatus specially prepared for the experiments was designed to lower the load quickly upon the beam in the first instance, and next to produce a considerable amount of vibration, as the large lever with its load and shackle was left suspended upon it, and the apparatus was sufficiently elastic for that purpose.

The girder subjected to vibration in these experiments was a wrought iron plate beam of 20ft. clear span, and the following dimensions :—

Area of top	4·30 square inches.
Area of bottom	2·40 „
Area of vertical web	1·90 „
Total sectional area	8·60 „
Depth	16 inches.
Weight	7cwt. 3qrs.
Breaking-weight (calculated)	12 tons.

The beam having been loaded with 6,643lbs., equivalent to one-fourth of the ultimate breaking-weight, the experiments commenced as follows :—

EXPERIMENT I.

Experiment on a wrought iron beam with a changing load equivalent to one-fourth of the breaking-weight.

Date.	Number of changes of Load.	Deflection produced by Load.	Remarks.
1860.			
March 21	0	0·17	Strap loose on the 24th March.
April 7	202,890	0·17	Strap broken on the 20th April.*
May 1	449,280	0·16	
May 14	596,790	0·16	

The beam having undergone about half a million changes of load by working continuously for two months night and day, at the rate of about eight changes per minute, without producing any visible alteration, the load was increased from

one-fourth to two-sevenths of the statical breaking-weight, and the experiments were proceeded with till the number of changes of load reached a million.

EXPERIMENT II.

Experiment on the same beam with a load equivalent to two-sevenths of the breaking weight, or nearly $3\frac{1}{2}$ tons.

Date.	Number of changes of Load.	Deflection in inches.	Remarks.
1860.			
May 14............	0	0·22	In this experiment the number of changes of load is counted from 0, altbough the beam had already nndergone 596,790 changes, as shown in the preceding Table.
May 22............	85,820	0·22	
June 9	236,460	0·21	
June 26............	403,210	0·23	The beam had now suffered one million chauges of load.

After the beam had thus sustained one million changes of load without apparent alteration, the load was increased to 10,486lbs., or $\frac{4}{9}$ths of the breaking-weight, and the machinery again put in motion. With this additional weight the deflections were increased, with a permanent set of ·05in., from ·23 to ·35in., and after sustaining 5,175 changes the beam broke by tension at a short distance from the middle. It is satisfactory here to observe that during the whole of the 1,005,175 chauges none of the rivets were loosened or broken.

The beam broken in the preceding experiment was repaired by replacing the broken angle-irons on each side, and putting a patch over the broken plate equal in area to the plate itself. A weight of 3 tons was placed on the beam thus repaired, equivalent to one-fourth of the breaking-weight, and the experiments were continued as before.

EXPERIMENT III.

Date.	Number of changes of Load.	Deflection in inches.	Permanent set in inches.	Remarks.
1860.				
August 9 ...	158	....	....	Tbe load during these chauges was equivaleut to 10,500lbs., or 4·6875 tons at the centre. With this weight the beam took a large but unmeasured set.
August 11...	12,950			During these changes the load in tbe beam was 8,025lbs., or 3·58 tons.
August 13...	24,900	0·22	?	
August 13...	25,900	0·18	0	Load reduced to 2·96 tons, or $\frac{1}{4}$th the breaking-weight.
December 1.	768,100	0·18	0·01	
1861.				
March 2 ...	1,602,000	0·18	0·01	
May 4	2,110,000	0·17	0·01	
September 4	2,727,754	0·17	0·01	
October 16...	3,150,000	0·17	0·01	

At this point, the beam having sustained upwards of 3,000,000 changes of load without any increase of the permanent set, it was assumed that it might have continued to bear alternate changes to any extent with the same teuacity of resistance as exhibited in the foregoing table. It was then determined to increase the load from one-fourth to one-third of the breaking-weight; and accordingly 4 tons were laid on, which increased the deflection to ·20.

EXPERIMENT IV.

Date.	Number of changes of Load.	Deflection, in inches.	Permanent set, in inches.	Remarks.
1861.				
October 18...	0	0·20	0	
November 18	126,000	0·20		
December 18	237,000	0·20		
1862.				
January 9 ...	313,000	....	....	Broke by tension across the bottom web.

Collecting the foregoiug series of experimeuts, we obtain the following summary of results :—

SUMMARY OF RESULTS.

No. of Expt.	Date.	Weight on middle of the beam, in tons.	Number of changes of Load.	Strain per square inch on bottom.	Strain per square inch on top.	Deflection, in inches.	Remarks.
1	From March 21 to May 14, 1860...	2	596,790	4·62	2·58	·17	
2	From May 14 to June 26, 1860.........	3·50	403,210	5·46	3·05	·23	
3	From July 25 to July 28, 1860.........	4·68	5,175	7·31	4·08	·35	Broke by tension a a short distance from the centre of the beam.
	BEAM REPAIRED.						
4	Aug. 9, 1860	4·68	158	7·31	4·08	...	The apparatus was accidentally set in motion.
5	Aug. 11 & 12	3·58	25,742	3·59	3·12	·22	
6	From Ang. 13, 1860, to Oct. 16, 1861	2·96	3,124,100	4·62	2·58	·18	
7	From Oct. 18, 1861, to Jan. 9, 1862	4·00	313,000	6·25	3·48	·20	Broke by tension as before, close to the plate riveted over the previous fracture.

From these experiments it is evident that wrought iron girders of ordinary construction are not safe when submitted to violent disturbances equivalent to one-third the weight that would break them. They, however, exhibit wonderful tenacity when subjected to the same treatment with one-fourth the load; aud assuming therefore that an iron girder bridge will bear with this load 12,000,000 changes without injury, it is clear that it would require 328 years at the rate of 100 changes per day beforc its security was affected. It would, however, be dangerous to risk a load of one-third the breaking weight upou bridges of this description, as, according to the last experiment, the beam broke with 313,000 changes; or a period of eight years, at the same rate as before, would be sufficient to break it. It is more than probable that the beam had been injured by the previous 3,000,000 changes to which it had been subjected; and assumiug this to be true, it would follow that the beam was undergoing a gradual deterioration which must some time, however remote, have termiuated in fracture.

CHEMICAL SOCIETY.

ON THE COMBUSTION OF IRON IN COMPRESSED OXYGEN.*

By E. FRANKLAND, F.R.S.

Whilst oxygen was being compressed into a Natterer's apparatus, recently supplied to the Royal Institution from Vienna, an accident occurred, which deserves to be placed ou record, owing to the interesting relations of iron to highly compressed oxygen revealed by it. The accident occurred in the following manner:—Oxygen was liberated from pure chlorate of potash, heated iu a florence flask, and was collected in a floating bell-gasholder, whence it was drawn through a flexible tube, and pumped in a strong wrought-iron receiver, of ·62 litre capacity, and weighing 2·775 kilogrammes. When about 25 atmospheres of oxygen had thus been introduced into the receiver, a sharp explosion occurred, followed by a shower of brilliant sparks, which lasted for several seconds. On examining the apparatus, it was found that the union-joint connecting the pump with the receiver, had given way, allowing the compressed gas to escape from the latter. The pump-head, containiug the valve, was slightly scorched internally. The steel tube connecting this head with the rcceiver, was very hot, and had obviously been in a state of active combustion, as it was coated internally with a layer of fused oxide of iron, whilst its bore had increased to at least three times its original size, and iu two places the tube was even perforated. The recciver was also heated, although not to such an extent as to be unbearable to the hand. On examining its interior, it was

* From the *Journal of the Chemical Society.*

found that the combustion had been propagated to the steel cap, the narrow passage in which was hollowed out into a capacious chamber, whilst the steel screw-valve had been completely consumed. The combustion had not, however, stopped here, but, extending into the receiver itself, had seized upon the internal walls of the latter, and covered them with fused globules of magnetic oxide of iron, and there can scarcely be a doubt, that, had the union-joint not given way, and thus furnished an outlet for the compressed oxygen, the latter would, in a few seconds more, have converted the receiver into a most formidable shell, the almost inevitable explosion of which would have scattered fragments of intensely ignited iron in all directions.

Regarding the primary cause of this explosion, there can scarcely be two opinions. The piston and valves were lubricated with olive oil, and the latter, becoming ignited by the heat of the compressed gas, had communicated its combustion to the steel and iron of the apparatus. Although the pump and receiver were not artificially cooled, yet this circumstance did not in all probability contribute materially to the ignition, because the oxygen was very slowly pumped into the receiver, the operation having to be frequently interrupted, to wait for the necessary quantity of gas which was being contemporaneously generated. Moreover, I had ascertained, immediately before the explosion, that the receiver was quite cold, and the head of the pump only just perceptibly warm. A few days previously, 60 atmospheres of oxygen had been with impunity *rapidly* pumped into the same receiver, and equally without any external refrigeration. How, then, is this difference of result to be accounted for? The answer to this question is not difficult, when an apparently trivial alteration of the condition of the apparatus, in the two operations, is known. In the directions for the use of Natterer's apparatus, contained in the article "Kohlensaure" (*Handworterbuch der Chemie*, Band. iv.), the writer states, that before the pumping commences, the space between the piston and the valve should be filled up with oil, so as to prevent the retention of any gas between the piston and valve, when the former, in compressing, is pushed to the extreme limit of its stroke. Any gas so remaining in such space (*schadlicher Raum.*), expands again on the return of the piston, and thus causes, if not an actual loss of power, at least a considerable retardation in the compressing process. In the operation above described, in which 60 atmospheres were compressed with impunity into the receiver, I omitted to follow this part of the directions of the *Handworterbuch*, whilst in the subsequent experiment in which ignition occurred, a layer of olive oil, about 0·1 inch thick, was poured upon the piston, so as exactly to fill the space above-mentioned.

Now, a careful examination of the burnt parts of the apparatus, leaves no doubt that the combustion commenced in the space between the piston and valve, and that it was this layer of oil which first became ignited. The compression of oxygen to $\frac{1}{25}$th of its volume should, according to thermo-mechanical laws, raise the temperature of the oxygen to upwards of 2,000° C., but after making due allowance for the loss of heat to surrounding surfaces, there still remains a temperature sufficiently high for the ignition of oil under favourable circumstances. If the oil be spread as a thin film upon the surface of a mass of metal, the rapid absorption of heat by the latter prevents the temperature of the oil from rising to its igniting point; but, in the form of a layer, 0·1 inch in thickness, no such rapid refrigeration can occur, and the surface of the oil, in contact with the gas, may become ignited by the rapid communication to it of the high temperature of the compressed oxygen. It is also not improbable, that traces of chlorate of potash, which are always carried over with oxygen when the latter is rapidly evolved, may have found their way into the pump, and contributed, to some extent, to the ready inflammability of the oil. However this may be, the result ought to be regarded as a caution against the use of combustible lubricants in the compression of oxygen or nitrous oxide. If ignition of the oil occur at high pressures, it will assuredly be communicated to the iron of the receiver, which evidently burns in oxygen compressed 25 times, with at least the same facility as tissue-paper in atmospheric air, the condition of the various parts of the apparatus, after the explosion, leading to the conclusion, that the combustion from the beginning to end, occupied only a very short time, probably not more than 3 or 4 seconds. The risk attending the compression of oxygen and nitrous oxide, may be avoided by the employment of a non-combustible lubricant. For this purpose, a strong solution of soft-soap in distilled water, appears to answer very well.

The facility with which a mass of iron thus becomes ignited, and the rapidity with which it burns in oxygen, at high pressures, suggests the possibility of employing shells of wrought or cast-iron charged with compressed oxygen, for warlike purposes. The interior of such a shell would scarcely be more difficult to ignite than gunpowder, and, once ignited, the pressure of the enclosed oxygen would, notwithstanding its absorption, be for some time augmented by the intense heat, whilst the walls of the shell would become thinner, until they finally burst into fragments of burning and semi-molten iron. The condition necessary to secure such a result, may be determined from the known absolute thermal effect of iron in oxygen. Andrews found that the union of one litre of oxygen with iron, produces sufficient heat to raise the temperature of 5,940 grammes of water through 1° C. It hence follows, that 780 cubic inches of oxygen, by combination with iron, would evolve sufficient heat to raise 1lb. of cast-iron to its melting point. This amount of oxygen introduced into the receiver above described, would exert a pressure of 20·5 atmospheres, consequently it would require the union of a quantity of oxygen exerting a pressure of 125 atmospheres, to raise the whole of the receiver to the melting point of cast-iron. These conditions are not encouraging; for, although a less amount of oxygen than that required for the complete fusion of the shell would suffice for the purpose required, yet it would doubtless be necessary to augment the thickness of such a vessel when used as a projectile, and this would necessitate a corresponding increase in the bursting charge of oxygen. Thus, little could probably be effected with less than 100 atmospheres of oxygen forced into the shell,—a pressure, which, I fear, would prove not only dangerous, but unmanageable.

THE BRADFIELD INUNDATION.

Result of the Inquest at Sheffield.

At the inquest held on the body of Thomas Ellstone and others, the following evidence was adduced:—

Mr. J. T. Leather, the consulting engineer of the Sheffield Waterworks Company, stated that to get a good foundation he sank to a depth varying from 10ft. to 60ft. The embankment across the valley is 418 yards long. It is about 500ft. wide at the base, and rather more than 12ft. at the top. The inner slope is $2\frac{1}{2}$ to 1 and the outer slope the same. The greatest height is 95ft., the puddle is 4ft. wide at the top, and gets wider by $1\frac{1}{2}$in. at every foot in depth. There is 60ft. of puddle below the surface, making the total depth of the puddle wall 155ft. The reservoir would contain a little more than 114,000,000 cubic feet of water. The surface area of water was about 78 acres. The area of the gathering ground is about 43,000 acres. There are two 18-in. pipes passing from the inside to the outside of the reservoir underneath the embankment. The pipes are about 500ft. long, made up of lengths of 9ft.; they are joined with sockets and lead in the ordinary way; they are laid in a trench 9ft. below the surface of the ground, and are wrapped round with clay puddle to about the thickness of 18in. The pipes are laid obliquely across the embankment in a straight line, the valves being at the lower end of the pipe, outside the embankment. If one of the pipes were to burst it would have to be reached by excavating to repair it. These pipes would run off 10,000 cubic feet per minute, and nine days would be required to let off the whole of the water. The embankment of the upper dam at Redmires is much larger than at Bradfield; though the plans and sections for both are precisely the same in principle. The pipes had not been examined since the flood, though he believed there was no leakage, as there was a full flow of water through the pipes when the valves were open. The weight of the water is measured by the depth, and not the quantity of the water on the superficial area. One-fourth the water might have given quite as great a pressure if the depth had been the same.

Mr. John Gunson, the acting-engineer for the company, then stated that the materials for the embankment were not taken indiscriminately from the banks of the reservoir, and tipped on to the embankment. First, 24,000 cubic yards entirely of stone, were placed on the outward slope of the bank, the stone forming an embankment itself up to within 50ft. of the top of the embankment. The object was to prevent the embankment slipping on the surface it was placed on, and to get that done effectually, 3*d*. per yard additional was paid for the work. The work was somewhat similar to that which is going on at present at the Agden Reservoir. The material is also generally the same.

Mr. Rawlinson, Government Inspector, said that some calculations had been prepared with regard to the flood. The total fall from the dam-head to Owlerton was 450ft., or 72ft. per mile. The velocity between those points of the flood was 18 miles per hour, showing that the water passed at the rate of $26\frac{1}{2}$ft. per second. The average area of the cross sections of the flood between the same points was 3,780ft., showing that 40,170 cubic feet of water passed per second. At this rate the reservoir would empty itself in 47 minutes; the weight of water was 3,250,000 tons. After the dam broke, a Derby horse could not have carried the warning down the valley in time to be of service.

Mr. Matthew B. Jackson stated that he was of opinion that no fault was to be found with the quantity of material on the slopes—the material was ample and the slope sufficient, but in his own practice he would have preferred a slope of 3 to 1 inside. The puddle was good and sufficient. He had also no fault to find with the by-wash. In forming an embankment he would have forbidden the use of railway waggons on a bank, more especially on the inside slope. Railway waggons always travel in the same line and tend to consolidate the embankment unequally, whilst carts travelling in different parts tend to consolidate. He also thought, the puddle trench, a good job, but he did not approve of the plan of putting in the pipes. Mr. Jackson had not the least doubt the proximate cause of the bursting of the reservoir was the drawing of the joints of one or more of the pipes, or both causes, together. It is possible there might have been a leakage through a fissure inside coming out of the embankment.

Mr. B. Smith then stated that from his experience at Melbourne and here, it seemed to him foolish to place pipes under an embankment.

Mr. Rawlinson was of opinion that the water as it rose would penetrate the bank, and search out its weakest point. The reason the embankment did not show signs of failure on the first admission of the first 40ft. of water would arise from the fact that the lower half, being upwards of 200ft. wide, may have been sufficiently tight to prevent any access of water to the puddle wall. As the water rose foot by foot in the reservoir it narrowed the intervening space between the water and the puddle wall $2\frac{1}{2}$ft.; and from his inspection of that bank, and from its state as it exists now, to be seen by any one, it is obvious that the upper half of the bank is not made of water-tight material, but contains a very large porportion of rubble stone. He measured some not on the surface more than 4ft. long, 2ft. wide, and 9in. thick. The water would thus penetrate to

puddle wall, gradually creep vertically down the face of the puddle wall, and inevitably find out the weakest point. On the opposite side of the puddle wall there is the same defective arrangement of rubble stone, dangerously close to the puddle wall. That this was so through the deepest part of the bank is evidenced by the description of the ultimate breaking down of the top of the bank. The first top water has been described as coming over in sheets and waves of foam. The water did not flow down the slope of the embankment, but was absorbed vertically into it.

The verdict was as follows:—"We find that Thomas Ellstone came to his death by drowning in the inundation caused by the bursting of the Bradfield Reservoir on the 12th of March, that in our opinion there has not been that engineering skill and that attention to the construction of the works which their magnitude and importance demanded; that in our opinion the Legislature ought to take such action as will result in a Governmental inspection of all works of this character, and that such inspection ought to be frequent, regular, and sufficient; and that we cannot separate without expressing our deep regret at the fearful loss of life which has occurred from the disruption of the Bradfield Reservoir."

THE ENGINES OF THE UNITED STATES FRIGATES "WAMPANOAG," "AMMONOOSUC," AND "NISHAMINNY."

These vessels are intended to be very fast. They are to have fine models and enormous engine power, and are expected to be a great acquisition to the Navy Department. The vessels themselves are of an entirely different class from any previously built for the service, being immensely larger than the new sloops, with heavier engines and larger boilers than any war vessels afloat, not excepting the *Dunderberg* and *Puritan*. The size of the cylinders and stroke of piston remains the same in all the ships just named, but the plans of the engines necessitate an immense additional weight, which might be dispensed with. They also occupy nearly the whole of the lower part of the ship, 247ft. out of 340ft. being devoted to the engines and boilers alone.

The hulls are 340ft. over all, 17ft. depth of hold from water line, and 44ft. 6in. beam. They are not iron clads. The models are intended to be good for speed; this quality being the first consideration. The floors are nearly flat, and there is but little bilge where the sides rise. The frames of the *Wampanoag*, building at the navy yard at Brooklyn, are all up, and it was intended to have launched the vessel early in the spring, but the matter is somewhat delayed, we are told, at present, and no period is fixed for the time of completion.

The plan of the engines is horizontal. They are also geared to the screw shaft at about 2 to 1, or twice as many turns of the propeller as the engine shaft makes. The cylinders are two in number, 100in. in diameter by 4ft. stroke of piston, and are placed horizontally, working athwart ships. The connecting rod proceeds directly from the cross-head, as in all other horizontal engines, and takes hold of the crank pin in the same manner. On this shaft there is a large spur wheel, built up in nine sections, each section being one wheel itself, having teeth of lignum vitæ, or young hickory, boiled in oil. The diameter of this wheel is 10ft. 3in., 3 5-16th of an inch diameter at the pitch line. There is one surface condenser, which is common to both engines, and is situated between them. In this there are to be 7,168 turned brass tubes 6ft. 3½in. long. The main steam valves are slides, worked by a Stevenson link. The valve face is on the side of the cylinder, and has an enormous area—the dimensions being 84½in. wide by 5ft. 6in. in length. The valve is of the double-ported variety, and is carried on 17 hardened steam rollers 2½in. in diameter, and 4in. long. These rollers run on guides, and are intended to relieve the stern from the enormous weight and friction of the valve. The steam ports are 82in. long by 2¼in. wide, and the exhaust ports 4in., by the same length, of course. The central exhaust is 18in. wide. There will be 3in. lap on the steam side and 1½in. on the exhaust side of the valve.

The propelling wheel is fixed in its place and can only be disconnected from the engines by a clutch coupling inside the ship. The thrust is taken by a large bearing having a number of collars, and there is also a roller bearing in addition. This latter consists of a number of steel balls working between two grooved couplings or disks. The diameter of the propeller is 18ft. and the pitch is expanding, having a mean of 25ft. The wheel is four bladed, and has no out board bearing on the extreme after end.

There are no less than eight main boilers in each of these ships, having one moke pipe serving for two boilers, or four in all. The pipes are 56ft. high from the uptake, 7ft. 8in. diameter for the large boilers, and 6ft. 6in. for the two forward boilers, which are smaller than the others. The safety valves are 8in. diameter of opening, and each boiler has one. The boilers are of Martin's patent, with a total water heating surface of 28,300ft. and a grate area of 1,128 square feet. There are 16,082 vertical tubes, and 744 horizontal tubes in all the boilers, also seven furnaces in each one. Steam is to be used superheated in these engines, and there are four superheating boilers near the engines, having a heating surface of 2,848ft. All the boilers are to be tested at a hydrostatic pressure of 65 pounds to the square inch. By an Act of Congress, the working pressure of steam boilers may be ⅔ the tested pressure. These engines can therefore have, in round numbers, 50 pounds of boiler pressure per square inch applied to them, provided the boilers stand the test. It is hardly necessary to say that this enormous pressure has never yet been applied to engines of a similar size. The boilers and engines are all to be of the best materials, and the cylinders and valve faces as hard as tools can work them, all bolt holes are to be rimmed, and the workmanship otherwise according to the most approved principles of modern engineering practice.—*The Scientific American.*

CORRESPONDENCE.

We cannot hold ourselves responsible for the opinions of our Correspondents.

SAFETY LOCOMOTIVES FOR SHARP CURVES.

To the Editor of THE ARTIZAN.

SIR,—In the ARTIZAN of February I called your attention to the subject of Mr. Bridges Adams' having patented, and, with the assistance of Mr. Cross, was attempting to appropriate to his own gain and credit my "Self-adjusting axle for locomotives," which you published in the ARTIZAN four years before Mr. B. Adams patents what he tries to claim as his design.

I wrote to the same effect to the *Engineer*, and if you and your readers will take the trouble of looking over the correspondence, &c., which appeared on this subject in the *Engineer*, you will at once see that the Editor, in his treatment of the subject, throws aside the usual impartial neutrality belonging to his office as Editor, and enters as a combatant into the case, but, at the same time, with the vested power belonging to his office of umpire or judge. Had I not had right on my side, it would have been in vain for me to have attempted to contest the case against such a combination as Messrs. Cross, Adams, and the *Engineer*; but as it was, and knowing also that I could not be accused of selfish motives, but that I was defending the case on public grounds only, I fought the case, as I think all will allow, to a successful issue, and left the "Self-adjusting axle," as I at first intended, public property.

The Editor of the *Engineer* evidently saw when too late his mistake, and awkwardly tries to get out of the scrape by talking of defending "Euclid," but will find it as difficult a task to show where "Euclid" insists on an inclined plane being a curved surface, as that Mr. B. Adams "origiual invention" is not a barefaced copy of my design.

I am Sir, your obedient Servant,
EDWARD STRONG.

Caledonian Railway, Carstairs, 15th March, 1864.

THE HYPOTHESIS OF MOLECULAR VORTICES.

To the Editor of THE ARTIZAN.

SIR,—As the article on Thermodynamics in the *North British Review* is, perhaps, the most complete history of that science which has yet appeared, and is written with a scientific precision which is unusual in journals not specially devoted to science, I wish to correct an oversight that the reviewer has committed in describing the "Hypothesis of Molecular Vortices," or "Centrifugal Theory of Elasticity," as proposed be me in 1849.* He speaks of atmospheres of ether surrounding nuclei of ordinary matter; whereas in the hypothesis, as I put it forward, the nuclei perform the functions of ether, and the atmospheres those of ordinary matter. Radiance is supposed to consist in oscillations of the nuclei, transmitted in waves by means of the forces which they exert on each other at a distance; and thermometric heat is supposed to consist in an agitation of the atmospheres, producing outward pressure according to the known laws of centrifugal force. Emission of radiance takes place when the atmospheres whirl faster than the nuclei oscillate, so that the nuclei are undergoing acceleration, and the atmospheres retardation; absorption of radiance takes place when the nuclei oscillate faster than the atmospheres whirl, so that the nuclei are undergoing retardation and the atmospheres acceleration. In perfect gases the nuclei oscillate with little impediment from the atmospheres, and the transmission of radiance is rapid; in substances in a more dense condition, each nucleus is, as it were, loaded with a part of its atmosphere (like a pendulum in resisting medium), and the transmission of radiance is slower. It is this peculiar view of the respective functions of the nuclei and the atmospheres that constitutes the main distinction between the hypothesis put forth by me, and other hypotheses involving atomic nuclei and atmospheres (as that of Mossotti), or accounting for the pheuemena of heat by molecular motions (as that of Mr. Herapath).

Of course a mechanical hypothesis does not form an *indispensable* part of Thermodynamics, more than of any other physical science; but if a hypothetical theory of thermodynamics is to be used, it appears to me that its fundamental principles must be such as I have described.

I am, Sir, your most obedient servant,
W. J. MACQUORN RANKINE.

Glasgow, 1st March, 1864.

To the Editor of THE ARTIZAN.

SIR,—Professor Pepper's *ghost*, as is now well known, is produced by reflection at the surface of a plate of unsilvered glass. In order to hide the object, the image of which is termed *the ghost*, and which I shall call *the object*, it is necessary that the plate of glass be inclined to the vertical; the consequence of this is that the object and the image, or *ghost*, are inclined to one another at an angle which is equal to twice the angle of inclination of the plate to either. If, then, one of the two be vertical, the other cannot be so, so that the image, or *ghost*, can only be made vertical by having the object inclined. This is comparatively of little importance so long as the *ghost* is to be stationary, but if it be intended to make it walk or dance, this can only be effected by having the object in a natural, and, therefore, the *ghost* in an unnatural attitude. All this can be avoided by a very simple modification of the original method, in which, so far as I am aware, I have not been anticipated, and which I have experimentally tested. Let a plane mirror be placed parallel to, and at a lower level than, the plate of unsilvered glass. The object then being placed *vertically* at this lower level, and so arranged as to cast no *direct* image on the glass plate, its

* Transactions of the Royal Society of Edinburgh, 1850-51.

image on the mirror will be inclined to it at such an angle as to produce by a second reflection in the plate, a vertical image of itself. This *second* image is *the ghost*, and by very elementary mathematical reasoning it may be shown that, if the objects move along the horizontal plane on which it is placed, the *ghost* will also move horizontally, while, by bringing the mirror nearer to, or farther from, the plate, the ghost may be depressed or elevated, so that it may be made to appear to rise from, or sink into, the floor, and to float upwards, or descend through the air.

I am, Sir, your obedient servant,
ARTHUR HILL CURTIS, LL.D.
Professor of Natural Philosophy in the Queen's University.
Queen's College, Galway, February, 1864.

REVIEWS AND NOTICES OF NEW BOOKS.

The Indicator and Dynamometer; "With their Practical Applications to the Steam Engine." By THOS. J. MAIN, M.A., F.R.A.S., Prof. R.N. College, Portsmouth; and THOS. BROWN, Assoc. Inst. C.E., Chief Engineer R.N. attached to the R.N. College. Fourth edition. London: Longman and Co., Paternoster-row. 1864.

We have noticed the previous editions of this work, the fourth edition of which has already just been published, which in itself is an evidence of the usefulness of the work.

The Mechanics', Machinists', and Engineers' Practical Book of Reference adapted to, and for the Use of, all Classes of Practical Mechanics; "Together with the Engineers' Field Book, with a collection of valuable recipes." By CHARLES HASLETT, C.E., and CHARLES W. HUCKLEY, Professor of Mathematics in Columbia College, New York (U.S.). London: Trubner and Co., Paternoster-row.

A useful pocket-book containing the usual tabulated matter, and treating of the usual subjects to be found in every other "Engineers' Pocket-book," and a vast deal that is useful not to be found in pocket-books of any kind or description. There is also a very miscellaneous collection of recipes for making or doing all kinds of things, including one for dyeing and another for stiffening *hats*. It is, indeed, a very useful book.

The Navy of the United States: An Exposure of its Condition and the Causes of its Failure. By E. N. DICKERSON. New York: J. A. GRAY and GREEN. 1864.

This pamphlet is devoted to a speech—and a precious long one it is—delivered to a jury in the Supreme Court of the District of Columbia, U.S., in the case of Mattingly *v.* the Washington and Alexandria Steam Navigation Company, recently tried before Chief Justice Carter.

From the title of the pamphlet one would suppose the author had really undertaken what is professed by an exposure of the condition of the United States' Navy, and the causes of its failure, and inferentially one might reasonably expect that something like a cure for the evil was intended to be modestly suggested by the author, but we have looked in vain; and, beyond a very lengthy speech, legal-advocate fashion, interspersed with an extra quantity of technical matter, and an abundance of figures (numeral and poetical) introducing a history of steam generation and of the steam engine from the philosophy of Marriotte, Biot, Guay, Lussac, and James Watt—whom the author designates the "Shakespeare of Mechanics"—down to the engines and engineers of the present day, there is a large proportion of the pamphlet devoted to the abuse of Mr. Isherwood, engineer-in-chief of the Navy Department of the United States, and a very able advocacy of the "patent cut off" of Mr. Sickles.

Mr. Dickerson's reputation as a very eminent barrister in the United States' Law Courts has long since reached this country; and, although the present pamphlet is full of virulent and violent denunciations directed against an individual or individuals officially connected with the Navy Department, the pamphlet contains a vast amount of well-strung-together matter, interesting more particularly to the elementary student in steam engineering.

The Sewing Machine: Its History, Construction, and Application. Translated from the German of Dr. Herzberg, by UPFIELD GREEN. London: E. and F. N. SPON. 1864.

Comparatively little has been written of the history of the sewing machine, and what has hitherto been done in the way of book making has either been with the object of advertising a particular kind of machine, or has been made up of a series of extracts from the specifications of patents—the one description of book being about as useless as the other to the practical mechanic or student desirous of acquainting himself with the mechanical details and proportions of parts of the various sewing machines which have been introduced.

Dr. Herzberg has taken a step in the right direction, by treating his subject in a systematic and practical way, and in the 112 pages of text, and seven large folding plates, has been able so perfectly to describe, not only the leading features or peculiarities of the several sewing machines, but has so minutely and accurately specified the whole of the parts thereof, their respective functions, proportions, and relations to each other, that any ordinary mechanic may forthwith proceed to construct any of the machines which the author has described and illustrated.

A recent legal decision, by a very high judicial authority, has rendered Dr. Herzberg's, work by accident as it were, of greater and more immediate practical value to the machine maker than otherwise it would have been, valuable as the book is; and as the tendency of the judicial authorities, in their decision in patent cases, appears to indicate a change of policy affecting property in patents for invention, it is just possible that the whole of the machines described so minutely by Dr. Herzberg may shortly become public property. And, in that way, as giving an impetus to a branch of machine making, may induce hundreds of comparative new machinists, in a small way of business, to adopt the manufacture of sewing machines as a business speciality.

The Year Book of Facts in Science and Art. By JOHN TIMBS, F.S.A. London: LOCKWOOD and Co. 1864.

Besides noting the most important discoveries and improvements of the past year, in mechanics and the useful arts, natural philosophy, electricity, chemistry, zoology, and botany, geology and mineralogy, meteorology and astronomy, &c., there is, in the present volume, an admirable portrait of Sir W. J. Armstrong, C.B., LL.D., &c., and an historical sketch of his life and progress.

The volume before us possesses extra interest, not alone from the additional number of facts recorded therein, but also from the carefully compiled index to the contents; and, excellent as the "Year Book of Facts" has been from the beginning, as a record of past and passing events, it has materially improved since it has been issued by the present publishers.

The Battle of the Standards. The Ancient of Four Thousand Years against the Modern of the last Fifty Years, the less Perfect of the Two. By JOHN TAYLOR. London: LONGMAN, GREEN, LONGMAN, ROBERTS, and GREEN. 1864.

A very interesting little book, devoted to the discussion of a subject which has for a long time occupied public attention, the question of the alteration of the standards of lengths, capacity, &c., upon which question, as on many others, there is much to be said on both sides.

NOTICES TO CORRESPONDENTS.

90 H.P.—Your calculation is correct in itself. As regards your question No. 2, it is so vague that we cannot undertake to answer it as it stands; a knowledge of intended speed, strength, &c., would be indispensable.

ZETA.—The Bessemer process of making cast steel without fuel direct from smelted pig iron of suitable quality, by blowing into the fluid mass—contained in a vessel constructed for the purpose—air under the necessary pressure for a few minutes, is now so great a commercial success that some six or seven large works are in active operation, producing steel in enormous quantities, besides others in course of erection.

ENGINEER (N.Y.)—We are obliged for the information contained in your letter. We certainly were not aware that Mr. R. Dudgeon obtained a patent in the United States as early as July, 1851, for hydraulic jacks and punches, identical with those described by Mr. Tangye in the paper read before the Institution of Mechanical Engineers. Send us the name in which you have been informed the invention was patented in England.

S.W.—We believe the address of Mr. Edward Richardson is "Railway Works, Lyttleton, Canterbury, New Zealand." Mr. G. Miller, late Resident Engineer of the Great Southern and Western Railway, of Ireland, is dead. We don't know the address of the other engineer.

ROD.—The following is a short description of a mill for making rods for wire drawing, and the way in which the wire rods are produced:—Three sets of rolls are placed alongside of each other, the first two sets consisting of three rolls of 8⅜in. diameter placed one above the other, the third set of two rolls, of same diameter, similarly placed.

The first set of rolls contain eight holes, viz., four between the two upper, and four between the two lower rolls.

The second set contains three holes, viz., two between the upper rolls and one between the two lower.

The third set contains one hole.

The billet (1⅝in. square) is passed egiht times through the first set of rolls, being inserted four times from each side alternately, between the two upper rolls from one side, and between the two lower rolls from the other side. While the rod is still passing through the eighth hole, it is bent round and inserted into the first hole of the second set of rolls, thus running through two holes simultaneously. After running completely through these holes, it is put into the second hole of the second set, and again bent round and put into the third hole, so as again to run through two holes together. After passing entirely through these two holes, the whole rod is run through the finishing hole in the third set of rolls. The four holes between the upper rolls of the first set are oval in shape; the four holes between the lower rolls of the first set are square in shape; in the second set the holes are diamond-shaped, square, and oval respectively; and the hole in the third set is round.

Obituary.

Mr. Richard Roberts, of Manchester, the eminent engineer, or more strictly the great mechanician, died in London, at Cecil-street, Strand, on Friday, the 11th March, in the seventy-fourth year of his age, and was buried at Kensal Green Cemetery on Saturday, the 19th March. His funeral, a public one, was largely attended by his friends and acquaintances—men eminent in the arts, sciences, and manufactures—and by many of his old pupils and workmen.

The name and great reputation of Richard Roberts is so world-widespread for the great mechanical genius he displayed during a long and

useful career, that it is almost superfluous for us to do more than announce the melancholy fact that this simple-minded man and great mechanic has heen taken from amongst us; for we know that hy far the largest proportion of our readers are more or less well acquainted with the wonderful brain-power and genius of that greatest of England's mechauics, and the enormous benefits he has conferred upon mankind—more particularly hy giving an extraordinary impulse to many manufacturing industries, he advanced rapidly the material progress of England and the world. Whilst Mr. Roberts patented many of his inventions, there were many others which he gave freely to the puhlic; and, although in many instances, he reaped some reward for his ingenuity and mechanical skill, the constant drain upon his inventive powers-inherent, also assisted to drain his pocket, for the genius of invention was never quiet within him; and, whiist millions upon millions of money have heen realised by the application of his inventions, we fear that his latter days were not "hlessed with worldly riches," nor has he left aught of "worldly gear" to provide for and maintain a devoted daughter, whose life has heen dedicated to soothing the declining years of her father, and prolonging his days hy carefully nursing and tending him. We trust that the same tardiness, lukewarmness, and possibly unworthy motives which (to the shame of some men, he it stated) prevented a proper and well-timed tribute to his genius—in the shape of substantial aid heing promptly made to Richard Roberts when he needed it—will not he suffered to operate with respect to the daughter of a worthy and great man.

To present anything like an accurate statement of the vast numher of inventions and contrivances made by Richard Roberts, arranged either chronologically or classified in a useful form for reference, would occupy too much space to permit of our doing so at this late period of the month at which we write, nor are the materials requisite to do justice to such a task sufficiently complete and in order; hut we purpose rather than give the crude and disjointed "story of his life" which has appeared in some other journals, to devote sufficient space in a future issue to do justice to the subject, aud put on record much that is interesting, hut generally unknown, concerning Richard Roberts and his mechanical skill and ingenuity.

BUILDING MATERIALS.—PRESERVATION BY MEANS OF THE RESIDUUM OF COAL-TAR.—In France, the residuum obtained by the distillation of tar, for the purpose of extracting the oils and hydrocarbons, is called *brai (coal-tar pitch* in English). Upon immersing bricks in this resin, melted at 200°, they become fit to use with success in the construction of chlorine chambers, also of condensers for chlorhydric acid. Mr. Kuhlmann, of Lille, has applied it hot to the exterior walls of his kilns for the decomposition of sea-salt, he also impregnates with it the tiles with which his workshops are covered, especially on those in which acid exhalations are produced. He also employs it for giving consistency and a black colour to vessels and tiles of porous earthenware. Plaster acquires a strong consistency, and does not crack as it does after being dipped in silicate of potash or soluble glass: by virtue of its porosity, it is thoroughly penetrated by the resin, and become permeable to all other substances; while objects moulded in plaster retaiu their form without the least alteration. This is so true that crystals of gypsum (natural hydrated sulphate of lime) become in the resin, of a shining black colour, the crystalline form not being changed but the water of hydration, being replaced by the resin: it is a pseudo-morph. Alabaster acts in the same way. Stones covered with coal-tar, or even with a greasy or resinous coating, resist the action of wind bringing salt spray from the sea better than do bare stones. Mr. Kuhlmann saw a striking example of this in the Bay of Biscay upon a building erected in 1858. Upon the more exposed points, the wrought stones were deeply corroded; but what is most remarkable of those stones which before being put in place, were numbered in black with oil, the parts covered by the colour have been so protected from alteration that the numbers are now presented in considerable relief and with great sharpness. This resin is not the only substance which readily penetrates plaster, stone, or masonry. Mr. Kuhlmann has discovered that resins, greasy matter, and various other substances act in the same way, and that it is also the case with all liquids and bodies in fusion, when they *wet* the body which is to be penetrated. In the case of plaster it is not a simple effect of permeability, but rather of displacement of the water; the plaster, becoming anhydrous, is thorougbly penetrated by the tarry matter, and its consistence increases, but the form of the object moulded is preserved unaltered, even when the bath of resin is raised to the temperature of 400° C. At from 150° to 200° C., stearic acid acts like resin; the plaster becomes impregnated with it, and at the same time loses its water of hydration, which is recognised from the boiling which it occasions in the bath. With liquids which do not wet the plaster, this penetration does not take place. Mr. Kuhlmann has tried in vain to effect it with melted sulphur or with mercury. But it is not only water which can be displaced by coal-tar; other substances are similarly affected: *e. g.*, crystallized peroxide of manganese loses, in the boiling resin, one atom of its oxygen, and takes up coal-tar; its crystalline form remains unchanged; after the operation, the crystals thus treated no longer give any trace of chlorine with chlorhydric acid. In all these experiments, the temperature of the solid body shonld be raised very gradually.—*American Journal of Science and Arts.*

RECENT LEGAL DECISIONS

AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

UNDER this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical hearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least —less experieuced artizan. With this object in view, we shall endeavour, as much as possihle, to divest our remarks of all legal technicalities, and to present the snbstance of those decisions to our readers in a plain, familiar, and intelligihle shape.

THE THAMES EMBANKMENT IN CHANCERY: MACEY *v.* THE METROPOLITAN BOARD OF WORKS.—This was a motion hefore Vice-Chancellor Wood to restrain the defendants from continuing their works in front of Milford Wharf, on the hanks of the Thames, until compensation was awarded to the plaintiff. The defendants had recently drawn up harges in front of the plaintiff's wharf, and commenced discharging chalk, stones, and ruhhish into the river, in order to commence the formation of the emhankment. The plaintiff insisted that they had no right to take this course until provisions for compensation were made, inasmuch as it amounted to a direct interference with his property. The Vice-Chancellor said that there appeared here to he no trespass whatever on the plaintiff's land, nor any act done which prevented his going again and using it. And in such case alone shonld an injunction go. There would he damage, no douht, but that was a question to he considered hereafter. He must refuse the motion. Costs to be costs in the cause.

FOXWELL *v.* BOSTOCK.—This case, relating to the validity of a patent, of which the plaintiff is assignee, for improvements in the construction of sewing machines, has heen several times hefore the Court of Chancery. The plaintiff in the case filed nearly 150 hills for alleged infringements of his patent, and after lengthened discussions the case hecame narrowed into the question whether the plaintiff's specifications sufficiently descrihed the invention claimed. The Lord Chancellor in giving judgment said that the question had heen argued at length hefore him. On a previous occasion he gave judgment, directing certain parts of the original specification to he struck out, and in his present judgment said that the comhination of machinery described in the amended specification was different from that descrihed in the specification for which the patent was granted. It was not easy to see what effect this had upon the patent itself. It was clear that an invention for which a patent was claimed might be reduced or diminished hut could not be enlarged under an amended specification. Some writers held that if the disclaimer violated the conditions of the statute which first recognised disclaimers it had the effect of rendering the specification itself void. But there was no authority on the subject. In the disclaimer it was recited that three auxiliary principles used in the combination which was claimed to he the invention were useful and novel at the time of the patent, and in the operative part so much was disclaimed as related to the means for regulating the supply of thread. Now, although these auxiliary principles were struck out from the amended specification, yet it was clear from the drawings that they were retained to describe the comhination for which credit was sought. The patent was descrihed to he for an improved arrangement or combination of machinery in sewing or stitching hy a needle and shuttle. Surely this improved arrangement indicates the nature of the invention itself. But it was the duty of the patentee to descrihe this improved arrangement; for in it lay the invention for which the patent was sought. It was contended that this improved aarangement was descrihed and defined in the drawings which accompanied the specification; hut, in reply to the contention, there was a ready answer that these drawings descrihed the entire machinery, without indicating in what the improvements consisted. To understand in what the improvements consisted would require a knowledge of all needle and shuttle machines which were known in England when the patent was granted, and without this knowledge it would not he possible to tell in what the improvements consisted. But the laws regulating patents required that a specification should be descrihed in such a manner as to he intelligible to an ordinary working man. The new combination for which this patent was claimed must be so descrihed that a person of ordinary knowledge should be able to make this machine and to learn hy what means it was to he worked. It was not, therefore, sufficient that a person acquainted with all sewing machines could he ahle to discover this invention. His lordship held that there was nothing in the specification which indicated in what consisted the improved arrangement. It was true that the argument was advanced that this was not necessary; but surely it was necessary that a specification should define the improvement hy virtue of which the patent was granted. At the time of this patent many combinations were known, and if in this state of things a patent was taken out for improved arrangements, the specification must show in what the improvements consisted. This obligation was not discharged hy showing the entire description of the machine, without distinguishing the particular improvement for which the patent was obtained. The words, "combination of machinery" were a favourite expression among patentees for the word machine, and any patent for an improved comhination of machinery must describe the improvements and define the novelty otherwise than hy a general description of the machine. He confessed that he had heen desirous to support the validity of the patent, hut regretted that he could not do so, and must hold that the specification of the patent was insufficient, and that the pateut was void. He had come to the conclusion independently of the evidence furnished hy the defendant, and if the plaintiff wished to appeal to the House of Lords the appeal would not require the attendance or examination of witnesses.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possihle, more especially with a view of benefiting those of our engineering hrethren who reside ahroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerahle assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect

and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

Lining Iron Tubes.—An invention has been patented by Mr. John Chatterton, of Highbury, which consists in lining tubes and hollow vessels, whether of iron or other metal or material, capable of resisting great pressure, with lead or other soft metal, or alloy, or gutta percha, or other material or composition capable of being rendered plastic by the application of heat, and in forcing the lining into intimate contact with the interior surface of the tube or vessel to be lined by means of internal pressure. He adopts different methods of operation, according to the nature of the tube to be lined, and the substance with which it is intended to line it. For instance, in lining iron tubes with lead he takes an ordinary length of iron tube, by preference a 12ft. length of wrought iron tube, and inserts therein a similar length of thin lead tube, taking care that the diameters and shape are such that the one will pass freely into the other. He brings the ends parallel, and drives or draws a short smooth conical mandril from one end of the tubes to the other, which mandril in its progress expands the inner tube till the outer surface thereof is in contact with the inner surface of the iron tube. This driving or drawing of the mandril may be effected by any of the well-known mechanical appliances suitable to the draw-bench, but he prefers thus to use hydraulic pressure. At the base of the conical mandril he fits a cupped leather, or a separate piston with a cupped leather attached; he inserts the said mandril and piston in one end of the inner tube, and upon the outer tube he screws a cap, having a pipe attached to it in connection with a force-pump. Such pressure of water is then applied against the piston as may be found necessary to drive the mandril from one end of the tube to the other. Sometimes he screws a stop to the further end of the tubes, to prevent the egress of the mandril. The pressure on the pumps can then be increased, and the tube further expanded (if necessary) by pressure of water alone. When the material to be lined may be rendered plastic by immersion in hot water, he inserts one tube within the other, in the manner described for lining iron tubes with lead, and then by means of caps he makes both ends water-tight. Into one of the caps he fixes a pipe in connection with a force-pump, and injects hot water at such a pressure as may be found requisite to expand the inner tube to the extent required. He then either suffers the water to cool or lets it escape through a stop-cock, and supplies its place with cold water by means of the same or another pump, so that the inner tube, by being reduced in temperature, may return to its normal condition of rigidity, but permanently retain its increased diameter. He makes a few small holes in the outer tube to permit the air between the two tubes to escape, as egress for it at the ends is cut off by the caps; these holes are easily plugged when the operation of lining is completed.

Subways.—Mr. Tite has laid before the House of Commons a Bill respecting the use of subways constructed by the Metropolitan Board of Works. It is proposed to give power to the Board to require that all pipes already laid or to be laid under the surface be laid in the subway; but in regard to the removal of a pipe laid under the surface before the construction of the subway there is a power of appeal to the Board of Trade on the question whether the pipe can be removed consistently with a due regard to the purposes for which it is used. All companies and persons are to have equal right, without favour or preference, so far as space will admit, to lay gas, water, or other pipes in the subways. The Board may demand rent for the use of the subways, the amount to be determined by arbitration in case of difference.

Thames Ironworks and Shipbuilding Company.—A prospectus has been issued of the Thames Ironworks Shipbuilding, Engineering, and Dry Dock Company, with a capital of £500,000, in shares of £100, to extend the business of the Thames Ironworks and Shipbuilding Company, established seven years ago at Blackwall, for which the consideration is to be £150,000 in paid-up shares, and £125,000 in 5 per cent. debentures. The property of the company comprises 20 acres of freehold, and it is proposed to purchase 8 acres additional to construct two graving docks. Three of the largest iron-clad frigates in the navy, the *Warrior*, *Valiant*, and *Minotaur*, were built at these works, and it is stated that contracts are now held to the amount of more than a million and a quarter sterling.

London Mortality.—A table has been compiled and laid before Parliament showing the mortality in the several districts of England in the ten years 1851-61. For all England and Wales the annual average mortality during that time was 2,217 per 100,000 living, or, as it is more commonly expressed, 22·17 per 1,000. In the Farnborough district in the South, and in Bellingham and Rothbury in the North (Northumberland), the annual mortality averaged less than 15 in the 1,000. The metropolitan returns give the following results, beginning with the City proper, then taking the surrounding districts, and lastly the more suburban parts. The returns are now corrected by distributing proportionally the deaths in hospitals, and corrected also for deaths in workhouses situated out of the districts to which they belong. In London City (within the walls) the average annual mortality in the ten years was at the rate of 2,222 to every 100,000 persons living; in East London (which, like the next district, is part of the City without the walls), 2,762; West London, 2,495; St. Luke's, Old-street, 2,736; Holborn, 2,641; Strand, 2,456; St. Giles's, 2,846; St. Martin's-in-the-Fields, 2,345; Westminster, 2,581; St. James's, Westminster, 2,290; St. George's, Hanover-square, 1,891; Marylebone, 2,404; St. Pancras, 2,232; Islington, 2,095; Clerkenwell, 2,309; Shoreditch, 2,421; Bethnal-green, 2,352; Whitechapel, 2,841; St. George's-in-the-East, 2,879; Stepney, Limehouse, and Mile-end, 2,553; St. Saviour's and St. Olave's, Southwark, 2,863; Bermondsey, 2,638; Rotherhithe, 2,527; St. George's, Southwark, 2,744; Newington, Surrey, 2,426; Lambeth (including Kennington, Brixton, &c.), 2,353. In the suburbs the mortality in Kensington (with Paddington, Hammersmith, and Fulham) was 1,985; Chelsea, 2,615; Hampstead, 1,760; Hackney, Stamford-hill, and Stoke Newington, 1,880; Poplar, Bow, and Bromley, 2,359; Greenwich, Deptford, and Woolwich, 2,449; Lewisham, Plumstead, &c., 1,787; Camberwell and Peckham, 2,319; Wandsworth, Battersea, Streatham, and Clapham, 2,194. For the metropolis generally, suburbs and all, the ratio was 2,363.

The Middle Level.—The leakage which occurred recently in the great dam so laboriously constructed near Lynn in the summer of 1862 has been stopped. It has been ascertained that there was not any defect in the syphons, as had been also supposed, but only in the flange of the tube connecting the air-exhausting pipe with one of the syphons. This defective flange has since been removed. The syphons continue to act satisfactorily, so far as it has been found necessary to use them, but the amount of rain-fall still continues below the average, and the efficiency and capacity of the syphons to pass the waters of the level in a time of heavy and continuous rain still remains to be tested.

The Cyclops Works.—Messrs. Charles Cammell and Co.'s extensive Iron, Steel, and Armour-plate Works at Sheffield, known as the Cyclops Works, have been transferred through Messrs. Chadwick, Adamson, and Co., to a joint-stock company, with a subscribed capital of £1,000,000 in shares of £100.

Allan's Automatic Smoke Consuming Apparatus.—Surrounding the arched top of the doors, and running parallel with them, are a series of eight small pigeon-hole openings. These are the ends of tubes which lead into the upper part of the furnace and in the direction of the firebed, and also upon a level with the zone of complete combustion of the furnace gases. These tubes are not straight, but are twice bent at an obtuse angle, their inner ends being all parallel to each other and to the direction of the furnace hearth. A piece of smoking brown paper applied to the ends of the tubes will show that a vigorous draft of air is passing in by them into the furnace, and that the tubes act like so many blowpipes; and the chimney top will at the same time show that no smoke is escaping from it meanwhile. The zig-zag direction given to the tubes carries the advantage of causing the incoming cold air to impinge upon the hot sides of the iron which forms them, and in this heated condition does the air pass into the furnace, resembling in principle the method of the hot-blast for iron furnaces. At the further end of the furnace, where the products of combustion escape into the flue, and thence up the chimney, there is placed an experimental pyrometer, which shows qualitatively the thermometric changes which occur in the furnace by the action or by the arrestment of the action of the air tubes. When the tubes are in free play, the temperature is sensibly higher, proving the economy of the fuel; when the tubes, with a view to experiment, are shut, the pyrometer shows that the temperature has fallen, and coincident with this smoke is abundantly formed. The graduation of the pyrometer in centigrade or Fahrenheit degrees would afford the ready means of proving these results quantitatively.

Galway and America.—The mail service between Galway and America has, until further notice, been suspended, by command of the Postmaster-General.

New Zealand Exhibition.—An exhibition will be opened at Dunedin, Otago, in January, 1865. The articles exhibited will be classed as in the International Exhibition. No detonating or dangerous substances will be admitted; and spirits, oils, acids, corrosive salts, and things of a highly inflammable nature only by special permission, and in well-secured glass vessels.

Utilisation of Gas in Coke Burning.—At the Selly Oak Nail Works, Birmingham, a new system of coke burning has been adopted, whereby the offensive and pernicious gases which usually escape to taint the atmosphere and injure vegetation, are turned to good account, by being conveyed to a neighbouring furnace or fire, either for blast-heating, generation of steam, or other purposes where they can be usefully consumed. The new process consists in connecting a series of coke heaps with flues leading into one main flue communicating with the steam boiler, the draught of which produces a beneficial effect; for as the coal heaps are lighted for burning into coke, the gas and sulphur thereby produced are drawn to the main flue, and from thence to the boiler, where they ignite and pass in streams of flame among the flues of the boiler, generating steam with very slight use of slack. There is a complete removal from the coal of all sulphurous properties, and thousands of tons of coal now considered of no use, may thus be converted into strong and good coke. The invention is patented by Messrs. J. and C. Hawkins, of Walsall.

Proposed New Weights and Measures.—The weights and measures to be authorised by Mr. Ewart's Bill, if it should pass, will be as follows:—Instead of the yard there will be the "metre," which will be about a yard and a tenth—39·371in., the other measures of length to be its decimal multiples or divisions; thus, on the one hand, there will be ten metres, called the "dekametre," and on the other the tenth of a metre will be the "decimetre," and so on. 1,000 metres, a kilometre, will be the nearest approach to the old mile; it will be nearly two-thirds of a mile—0·621. For square measure the unit will be an "are," which will be about 120 square yards—119·603; a "centiare" the hundredth part of an are or a square metre, will be the nearest to our square yard, being one-fifth more—1·126. 100 ares, a hectare, are 2·471 acres. For measures of capacity the unit will be the "litre," about a pint and three-quarters—1·761. Ten litres, a "dekalitre," will be two gallons and a fifth—2·201. The small drinker may take his "decilitre," about the sixth of a pint (0·176), or his "centilitre," which is the tenth part of a decilitre. For weights the unit will be a "gram," nearly 16 grains—15·433; 1,000 grams, a "kilogram," will be about 2lb. and a fifth of a pound—2·205; 1,000 kilograms, 2,204·714lb. will be a ton. The double and the half of all these measures and weights may also be used.

North Country and Welsh Steam Coal.—Reports of trials of Welsh and North of England steam coal have been laid before the House of Commons. Mr. Miller, chief engineer at the steam factory, Kesham, has made a full report of a series of experiments, extending over four months, and states as the result that it is evident that the introduction of North Country coals to be burnt in combination with Welsh coals, in equal portions, would be attended with desirable results, as by which means all the Welsh coals put on board a ship might be usefully and economically burnt, smoke prevented to a great extent, and a more rapid evaporation effected; that is to say, a given quantity of water, evaporated by a given quantity of coal, in less time, and thus the steam boilers of ships rendered more powerful. There would be no difficulty in coaling a ship with the two kinds of coal. The bunkers of one side might be filled with the North Country coal, and the other with Welsh coal. Mr. Anderson, engineer in charge of her Majesty's ship *Supply*, reports in favour of a mixture of from one-third to one-half North Country coal with Welsh. The consumption he found the same as Welsh coal, but there were fewer ashes. Commander Roberts, of her Majesty's store ship *Wye*, is in favour of one-third North Country coal. He tried a mixture in other proportions, but found this burnt less coal for a given amount of work, and produce considerable less smoke, ashes, and soot. Mr. Rumble, inspector of machinery afloat at Sheerness, states, as the result of experiments on board the *Fearless*, as well as of his experience when out on trial with vessels at the measured mile, during the last twelve months, that for economy of fuel, and producing the greatest amount of steam pressure, the best proportion is a mixture of two-thirds Welsh and one-third North Country coal, and that this is better than either kind of coal separately.

NAVAL ENGINEERING.

The Trial of the Ranger.—This vessel has undergone a trial of her speed and machinery down the river to the Maplin Sands. Six runs at full power were made at the Lower Hope, and four runs at half power at Long Reach, the result of which was a fraction under eight knots at full speed and six knots at half speed. The *Ranger* was paid out of commission by Commander Wratislaw, from the West Coast of Africa, on the 10th of November last.

Trial of Twin Screws.—The first of these two trials was a small vessel, the *Experiment*, built to order for the Admiralty for service at Ascension. The *Experiment* is only fitted with engines of 20 horse-power nominal, but in her two runs over the measured mile she realised 7·659 knots against the tide and 10·909 knots with the tide. Off Barking she took in tow a deep-laden schooner of 200 tons and towed her to the West India Docks against the tide at the rate of $5\frac{1}{2}$ knots. The *Experiment* is the first vessel fitted with twin screws in Her Majesty's navy. Her engines are horizontal direct-acting high-pressure, and drive two three-bladed propellers, having a diameter of 3ft. 8in. and a pitch of 7ft. 4in. The second vessel, named the *Edith*, has been built for commercial purposes, and is intended to cross the Atlantic. Her principal dimensions are:—Length, 175ft.; breadth, 25ft.; depth, $15\frac{1}{2}$ft.; draught of water, aft, 9ft. 6in.; forward, 6ft. 6in. Her engine-power is 200-horse nominal, and the cylinders have a diameter of 34in., with a 21in. stroke. The weight of the engines, with shafting, tubes, and propellers, is 64 tons, and that of the boilers 35 tons. The propellers, each driven by its own independent engine, have each three blades of the common form, with a diameter of 8ft. 6in., a pitch

of 16ft., and a length on line of keel of 2ft. 4in. The *Edith* left Gravesend at noon for Long Reach. On arriving in Long Reach, a run was taken over the measured mile each way, with and against the tide, the ship realising under the latter circumstances a speed of 11·803 knots, and with the tide 15 knots, the mean of the two runs being 13·401 knots, which was considered highly satisfactory. Her engines averaged 100 revolutions under 28lb. of steam pressure, and with a vacuum of $25\frac{1}{2}$in. The vessel's course was next kept down the river to obtain space for putting her through several manœuvres under steam, so as to exhibit the powers of twin screws in relation to military purposes. On reaching the position required the experiments were prefaced by making two complete circles with both screws going ahead, starting with the vessel's head upon tide. The first circle was made in 4min. 10sec., and the second in 3min. 57sec. The subsequent experiments, relating more entirely to military purposes, were commenced by starting from a state of rest with the starboard engine going astern and the port ahead, the helm being hard aport. The vessel turned a complete circle under these circumstances, with her own centre as the pivot, in 3min. 29sec., the mean revolutions of the engines being 84. The circle being completed, the engines were suddenly reversed to opposite directions, and their action upon the vessel was instantaneous, the revolving motion of the ship being checked and changed to the opposite direction with the greatest ease and nicety. The manœuvre was repeated several times, and the vessel thus represented a revolving battery mounted with monster ordnance, too heavy for training upon any given object by ordinary appliances. The hull became the carriage for such heavy guns, and trained them upon any given point by revolving under the action of the screws alone. The ship's course was next laid at full speed, both screws going ahead up the river, the supposition being that the vessel was carrying out hostile measures in the presence of an enemy, and that it suddenly became necessary to altogether alter the vessel's course and retrace her path down the river. The time was taken from the order "hard over" being given by the pilot, and in 1min. 40sec. the *Edith* was in a straight course in the required opposite direction. Continuing her course thus, the port engine was next stopped, and with the starboard continuing to go ahead the helm was put over, and a full circle made in 4min. 31sec., the revolutions of the engines being 79.

THE IRON FRIGATE "HECTOR," 4,123 tons, and 800 horse-power of engines, underwent her "commission," trial of speed, on the 23rd of February, at the measured mile in Stokes Bay, near Portsmouth. The *Hector* was first tested in making circles with full and half boiler power, with these results:—Full-power—helm to starboard, 12 men at the wheel, revolutions of engines, $57\frac{1}{2}$; time occupied in getting up the helm, 27sec.; angle of rudder, 20deg.; turns of wheel, $2\frac{1}{4}$; time in making half circle, 2min. 48sec.; ditto full circle, 5min. 49sec.; revolutions of engines, 55. Full-power—helm to port, revolutions of engines, $57\frac{1}{2}$; time in getting helm up, 25sec.; angle of rudder, 26deg.; turns of wheel, $2\frac{3}{4}$; time in making half circle, 2min. 41sec; ditto full circle, 5min. 24sec.; revolutions of engines, 56. With half-boiler power the full circle was made to starboard in 6min. 43sec., and to port in 5min. 49sec. The diameter of the circles was from two and a-half to three times the ship's length, and the ship was steered as easily as a boat. On the conclusion of the circle experiments the ship's head was laid for the trial ground of the measured mile in Stokes Bay to test her at the more important portion of her day's work, and obtain her average rate of speed under full and half boiler power over the course of the measured mile. The ship was drawing 24ft. 2in. of water forward, now that she was under steam and her anchor stowed, and 25ft. 8in. aft. The wind was light from N.E., the water smooth as a lake, the ship's machinery was working admirably, and everything was in the ship's favour. At full-boiler power the results were:—First run—time, 4min. 44sec.; speed, 12·676 knots; steam, $20\frac{3}{4}$lb.; vacuum, $26\frac{1}{2}$; revolutions of engines, $58\frac{1}{2}$. Second run—time, 5min. 12sec.; speed, 11·538 knots; steam, 22lb.; vacuum, $25\frac{1}{2}$; revolutions of engines, 59. Third run—time, 4min. 36sec.; speed, 13·043 knots; steam, 20lb.; vacuum, $25\frac{1}{2}$; revolutions of engines, 59. Fourth run—time, 5min. 13sec.; speed, 11·501 knots; steam, $21\frac{1}{2}$lb.; vacuum, $25\frac{1}{2}$; revolutions of engines, 59. Fifth run—time, 4min. 20sec.; speed, 13·846 knots; steam, 21lb.; vacuum, $25\frac{1}{2}$; revolutions of engines, $59\frac{1}{2}$. Sixth run—time, 5min. 35sec.; speed, 10·746 knots; steam, 22lb.; vacuum, $25\frac{1}{2}$; revolutions of engines, $59\frac{1}{2}$. The mean speed of the six runs was 12·358 knots. At half-boiler power the results were:—First run—time, 4min. 59sec.; speed, 12·040 knots; steam, 21lb.; vacuum, 27; revolutions of engines, 45. Second run—time, 7min. 6sec.; speed, 8·450 knots; steam, 21lb.; vacuum, 27; revolutions of engines, 48. Third run—time, 4min. 59sec.; speed, 12·040 knots; steam, 22lb.; vacuum, 27; revolutions of engines, 49. Fourth run—time, 7min. 7sec.; speed, 8·430 knots; steam, 22lb.; vacuum, 27; revolutions of engines, 49. The mean speed of the four runs was 10·242 knots. The temperatures were as follows:—In the first run, on deck, at full-power, 38deg.; at half-power, 44deg. In the engine-room—forepart, 74deg. at full-power, and 74deg. at half-power; middle, 64deg. at full-power, and 64deg. at half-power; aft, 68deg. at full-power, and 69deg. at half-power. In the stokehole—forepart, 94deg. at full-power, and 80deg. at half-power; middle, 109deg. at full-power, and 108deg. at half-power; aft, 103deg. at full-power, and 105deg. at half-power. In the last runs the maximum temperature in the engine-room was 78deg., and in the stokehole, 124.

NAVAL APPOINTMENTS.—The following appointments have taken place since our last:—W. Wynd, Engineer, to the *Decan*, coal depot; W. Rowley (a), Engineer, to the *Cumberland*, for Sheerness tug; W. Crichton, Assist. Engineer, to the *Princess Royal*; J. J. Nibbs, Assist. Engineer, to the *Indus*, as supernumerary; W. Oliver, Chief Engineer, to the *Asia*, for the *Royal Sovereign*, vice Taylor; W. J. Ibbett, Chief Engineer, to the *Asia*, for the *Prince Regent*: A. Dunn, Chief Engineer, to the *Pembroke*; Robert Roughton, Chief Engineer, R. W. Hulford, Engineer, and J. Adams, J. M'Kenzie, and J. T. Morgan, Assist. Engineers, to the *Bulldog*; W. Thomas, of the *Fox*, promoted to Engineer; J. B. Grant, Supernumerary, in the *Asia*, promoted to First-class Assist. Engineer; J. C. Robinson, Chief Engineer, to the *Indus*, for the *Zealous*; J. Coade, Chief Engineer, to the *Cumberland*, for the *Bombay*; J. Coope, Chief Engineer, to the *Orlando*; G. Glasson, Chief Engineer, to the *Indus*, for the *Brisk*; G. Lumley, Chief Engineer, to the *Research*; G. Kent, Chief Engineer, to the *Fisgard*, for the *Mutine*; J. R. Johnson, Chief Engineer, to the *Gladiator*; G. Thompson, Engineer, to the *Research*; E. Ingledew, Engineer, to the *Indus*, for the *Fervent*; W. Roberts, Engineer, to the *Gladiator*; J. Watson (a), Assist. Engineer, to the *Research*; T. Rose and J. Runnals, Assist. Engineer, to the *Gladiator*; J. Leathlean, Engineer, to the *Indus*, for the *Assurance*; M. Lambert, Engineer, to the *Fisgard*, for the *Racer*; E. Eckersley and J. T. Page, Engineers, to the *Euryalus*, additional, for disposal; W. Chase, E. Bennet, J. Pickles, A. M'Intyre, J. Brown (b), G. F. Greaves, S. H. Trenham, J. Lewthwaite, R. Pattison, and W. T. Pover, Assist. Engineers, to the *Euryalus*, additional, for disposal; J. Vercoe, Engineer, to the *Hastings*, for the *Sandfly*; G. H. Loxdale, Acting Engineer, to the *Hastings*, for the *Lark*; F. Holden, Assist. Engineer, to the *Colossus*; T. Pringle, Assist. Engineer, to the *Colossus*, for the tenders.

MILITARY ENGINEERING.

A COUPLE OF 300-POUNDER SMOOTH-BORE GUNS, with coiled tubes and solid ends, made in the Royal gun factories at Woolwich, have recently been proved at the Plumstead butt. The first gun proved was fired two rounds, with a charge of 50lb. of powder and a 600lb. cylinder shot, and two subsequent rounds with 35lb. of powder and a 300lb. cylinder shot. It was then ascertained that the shot could not be driven home. The fifth charge, partially loaded, was extracted, and on examination a flaw was discovered in the inner tube near the breech. The second gun withstood the test well.

EXPERIMENTS AT PORTSMOUTH.—On the 25th and 26th February, practice took place at Portsmouth from the guns of the *Stork* gunboat, with cast iron and steel shot from 68 and 100-pounder guns, the plates varying from 4ft. to 16ft. in length, and from $4\frac{1}{2}$in. to 6in. in thickness. The first day's firing was confined to cast iron shot (service) from the 68-pounder gun, with the usual service charge of 16lb. of powder, and the results were those usually obtained. The indents averaged $1\frac{1}{2}$in. in depth, and the shot in all cases destroyed themselves by the force of their own impact and the want of cohesive strength in their material. On the following day, firing took place at the undamaged portions of the same plates with crucible iron shots and crucible and Bessemer steel shots, from both the smooth-bore 95cwt. 68-pounder, and the 6-ton (9·22 bore) 100-pounder smooth-bore Armstrong. The first shot fired was from the 100-pounder gun, with a Woolwich Laboratory-made cast iron shot, and a 25lb. charge of powder, against a plate of $4\frac{1}{2}$in. made by John Brown and Co., of Sheffield, for the *Lord Warden*. This shot made an indent in the plate, the diameter of which was 10in., and its depth, $6\frac{1}{2}$in., the shot destroying itself without penetrating further into the target-ship's side. The second shot was made from Price's crucible iron, and was fired at the same plate from the same gun with a similar charge of powder. The diameter of the indent in this instance was also 10in., with a depth of 7in., the shot again being destroyed. The third shot was of steel, fired from the same gun, with a 25lb. charge against the *Bellerophon* 6-inch plate. This shot remained sticking in the plate with its outer surface projecting 2in. beyond the plate's outer surface, the shot itself being partially broken. Inside the ship a knee was started and two planks were broken. Two steel shots were next fired from the same gun, with similar charges of powder, against Messrs. Cammell's $5\frac{1}{2}$in. plate for the *Lord Clyde*. Both of these stuck in the plate, one projecting $4\frac{1}{2}$in. from the plate's outer surface, and the other 2 7-10in. The concluding shot from the 100-pounder was fired at the 6in. plate, and, as in the other instances, partially imbedded itself; the outer surface being 2 8-10in. outside the plate's outer surface. The 68-pounder gun was now brought into use, and a wrought iron case-hardened shot fired from it, with the usual service charge of 16lb. of powder, against Messrs. Brown and Co's plate, and produced the usual indent of a cast-iron projectile of this weight, of $2\frac{1}{2}$in., with a diameter of 9in. The next shot was of steel, fired also from the 68-pounder with a 16lb. charge. It was also fired at the same plate. It made an indent of its own diameter of 8in., with a depth equal to the plate's thickness. A subsequent shot shook this last out of its place from the plate overboard. The next steel shot from the 68 struck within 4in. of the last shot on Messrs. Brown's plate, and remained sticking in the plate 3 7-10in. outside the plate's outer surface, and shaking out the previous shot. The last shot fired struck the lower edge of the plate, and, passing inboard, glanced downwards, and went right through the ship's bottom, letting the water rush in. The plates fired at on the above two dates have received the following classification at the Admiralty:—

Manufacturer's Name.	Ship.	Description.	Admiralty Order of Merit.
John Brown & Co.	Lord Warden	$5\frac{1}{2}$in. rolled	A 1
Ditto	Ditto	$4\frac{1}{2}$in. ditto	A 1
Ditto	Royal Alfred	$4\frac{1}{2}$in. ditto	A 1
Ditto	Prince Albert, cupola ship.	$5\frac{1}{2}$in. ditto bent plate	A 2
Mersey Company	Agincourt	$5\frac{1}{2}$in. hammered	A 3, inferior
Ditto	Ditto	$5\frac{1}{2}$in. rolled	A 4
Charles Cammell & Co.	Lord Clyde	$5\frac{1}{2}$in. ditto	A 1
Millwall Company	Bellerophon	6in. ditto	A 3
Beale & Co.	Pallas	$4\frac{1}{2}$in. ditto	B 1

CASTING OF MONSTER GUN.—The 20in. Rodman gun, stated to be the largest piece of ordnance in the world, was, it appears, successfully cast on the 11th of February, at the Fort Pitt Works, Pittsburgh. The arrangements for the casting were on the most ample scale. The furnaces are three in number, two of them are calculated to reduce 25 tons of metal each, and the third, 40 tons at single heat. They are so arranged as to pour the metal into a reservoir, with the shortest length of "runners" possible. The flask in which the gun was cast is a massive piece of cast iron. It is of octagonal shape, formed of iron of $1\frac{1}{2}$in. in thickness, and thickly studded with supporting ribs of 6in. by 4in. It was cast in several sections, fitted together into halves, the opposite sides being left open for the filling of the mould. The entire casting weighs about 20 tons, and the mould, with sand and brackets, probably about 40. The construction of the patterns alone of the flask and gun occupied many weeks. The gun will be reduced in the iron lathe from a rough weight of 170,000lbs. to a finished weight, calculated, of 115,000lbs. The whole length from breech to muzzle will be 243·33in.; length of bore, 210in. The maximum diameter will be 64in., minimum 34in. The solid round 20in. shot will weigh 1,000lbs., and the shell about 700lbs. The charge of powder will vary according to circumstances, from 65lbs. to 80lbs. Some two weeks must elapse before the gun will be lifted from the pit, and many weeks before it will leave the lathe in a partially finished condition, to be chipped, filed, and fitted ready for mounting. The lathe in which the gun is to be turned is one of the most massive ever constructed. For its foundation, an excavation about 65ft. in length, 20ft. in width, and 13ft. in depth, was filled for 3ft. in depth by a thoroughly grouted mass of stone work. Upon this foundation were secured an immense bed plate, and the basis is of 30 cast iron columns, arranged in pairs, and supporting in turn the caps upon which the "shears" of the lathe rest. These columns are 8ft. high, and 10in. in diameter, and the "shears" cast in two pieces, are 18in. high, about 12in. face, and 65ft. long. They were placed about 5ft. apart, coupled by caps, and strung together by the shears. As soon as the immense castings were fitted and securely bolted to their places, the interior of the pit was solidly built up with brick laid in cement, forming a rigid mass from top to bottom, with a longitudinal pit extending from end to end. Nothing less than this rigid foundation could be used in the heavy work for which the lathe is designed. Upon the shears rest the ordinary tool slides, massive pieces of cast iron. The lathe will be drawn by a pair of 6in. cylinders, 12ft. stroke, and working at right angles. The driving wheel and face-plate is 9ft. in diameter, and so geared as to erect an enormous power. The weight of metal in the principal pieces composing the lathe is 289,085lb.

EXPERIMENTS AT SHOEBURYNESS.—Some experiments recently took place at Shoeburyness, to test the powers of the greatest gun yet forged by Sir William Armstrong against one of the thickest plates from the firm of Messrs. John Brown and Co. The gun was "Big Will," the 600-pounder. The mass of iron against which it was tried was 11in. in thickness. The real interest of the experiment consisted in ascertaining—first, whether the same destructive result would be gained by using the gun as a smooth-bore with a steel shot of half the weight; secondly, how the gun would stand the charge of 90lb. of powder; and, thirdly, whether the fracture of the plate would show that Messrs. Brown could manufacture one of 11in. in thickness perfect throughout. The plate or slab of iron was four feet long by three and a-half wide, and was unimpaired in its strength by a single bolt-hole or fastening. It was held up vertically against two 12in. beams of solid oak, to which it was fastened by railway iron passing up its face on either side. Behind it, and in support of the oak beams, was the Fairbairn target of 5in. plates and a 1in. inner skin, with the usual massive framework of iron rib beams. This target, however, did not support the plate to be fired at, but only the beams of oak which held

it in its position. There was an interval of 12in. between the plate and the Fairbairn target, which was left purposely that the former might do its own work if it could unaided. The proceedings were commenced by firing two cast iron round shot of 300lb. weight, levelled at 200 yards' range, against a "dummy" target placed close alongside the 11in. plate, for the purpose of determining the exact degree of elevation to be given to the gun. Both these were fired with charges of 90lb. of powder. The precise range having been ascertained, the gun was loaded with a steel round shot of 344lb. weight, and levelled against the target. This shot struck the very centre of the plate, at a velocity of 1,560ft., and at one blow closed the experiments for the day. Nothing further remained to be accomplished, for the target was gone. The solid oak beams behind the plate were crushed into splinters, and the plate itself hurled bodily back against the Fairbairn target and split into two pieces—one huge piece being flung away to the right and the other to the left, and this before the shot had time to penetrate to a greater depth than 4½in. A target was tested at this practice ground on the 16th ult. The target was one composed of compressed wool, made after Mr. Nasmyth's plan. The target, if we may so call it, was a wrought iron tube, like a boiler or iron funnel, open at both ends, 10ft. in diameter and about 11ft. long. The wool part of the target was was constructed by tilting this on one end and filling it with wool as tightly as men could trample it down till the cylinder was full. It was then laid on its side fronting the gun, so as to present the appearance of a large white circular target or drum, 10ft. in diameter and 11ft. thick of solid wool. The first shot was fired from the Armstrong 100 pounder with a 10lb. charge, and this not only passed through the target from end to end, but buried itself in the earth behind. A second shot was fired from the 68-pounder, with the usual service charge, and this also went through, burying itself in the bank.

Testing Armour-plates at Portsmouth.—On the 22nd and 23rd ult. some firing at armour-plates took place at Portsmouth, French as well as English manufactured plates being under trial. The first day's firing was confined to the common 95 cwt. smooth-bore 8in. gun, with solid cast iron shot and a 16lb. charge of powder. The result of this day's firing, which was merely to classify the plates in their order of merit according to the Admiralty regulations, was as follows:—1, a 6in. plate from Messrs. Beardmore, of Glasgow, a sample plate, hammered down to 12in., and finished under the rollers to 6in.; 2, a 4½in. plate from Messrs. Petin, Gaudet, and Co., France, rolled; 3, two 6in. plates from the Millwall Ironworks and Shipbuilding Company, for the *Bellerophon*, rolled; 4, a 4½in. plate from Messrs. Beale, of Parkgate Works, Sheffield, for the *Pallas*, rolled; and 5, a 4½in. plate from Messrs. Petin, Gaudet, and Co., France, rolled. On the second day the 9·22in. gun, smooth bore, commonly termed the 100-pounder Armstrong, was tested against the plates with steel shot. The first shot was fired with a charge of 30lb. of powder, and directed against one of the Millwall 6in. plates at its left, and where it had received no shots from the 8in. gun in the previous day's firing. The shot was made by Firth and Son, Sheffield. It struck the plate 12in. above the lower edge, and stopped, partially buried in the ship's side and partially in the plate, the outer surface of the shot being not more than half an inch outside the plate's outer surface. A second steel shot, manufactured by John Brown and Co., of Sheffield, was next sent against the plate, and struck on the same end. It also remained partially buried in the plate and partially in the ship's side. In this instance the outer surface of the shot and the plate were flush. In both cases the whole of the plate's back near the shot-hole was broken up. Penetration into the ship was not effected, and the plates had apparently done their duty in repelling such dangerous missiles as steel spherical shot even at the cost of their own destruction. On inspecting the inside of the ship, the damage done to the side at the back of the plate was found to be very serious. A space 16ft. in length by 4ft. in breadth was started, and bulged inwards from 4in. to 7in.; the whole was fearfully shaken. Indeed, so much was it shaken that probably one more steel shot, and certainly two more, would have sent this 16ft. by 4ft. of the ship's side with its armour-plate prostrate on the frigate's gundeck. A steel shot was next fired at Messrs. Beardmore's plate. It struck the plate's centre and projected 2in. from the plate's outer surface. There were no cracks, nor was any damage done to the inside of the ship at the plate's back. A shot was next sent at the second plate of the Millwall Company, but it flattened up in entering the plate, projected 2in., and its further progress was stopped. This finished the practice with the 9·22in. gun, and a closing shot was fired at the Norwegian ironplate from the 8in. gun. This shot stuck in the plate, its outer surface being 4in. outside the plate. It opened up deep cracks on the plate's lower edge. No damage was caused to the ship's side by this shot, as far as could be ascertained from the gundeck.

New Proposed System of Carrying Heavy Guns.—Plans have recently been submitted to the Lords Commissioners of the Admiralty by Capt. C. S. Dawson, Royal Fusileers, doing duty with the Royal Engineers on the national defences, for carrying 8 or 12 300-pounder guns (rifled) on the main deck of a ship as ordinary broadside guns, without in any way interfering with the vessel's masts, funnel casings, or the general arrangements of the decks. The plan for carrying eight guns shows five turntables on a line with the ship's keel, and five auxiliary or radial turntables on either broadside with two radial turntables at the bow and stern. Three of the central turntables are to carry two guns each. Each gun will serve four ports, as occasion may require. On the double turntable the guns are placed muzzle to breach, and by a half turn of the table are run on to their auxiliary tables in front of their respective ports, and trained by two men to any angle by the most simple mechanical means. The plan for carrying 12 guns is very similar to the former, the principle being the same, but the arrangement of the guns is different. There are in this case four central turntables on a line with the ship's keel, and 12 side tables at the ports. Three guns are carried on each of the central tables, and the whole armament of the ship is thus concentrated, when stowed as a sea-going weight, within a space of 96ft. in the centre of the ship, and the extremities of the ship are thus materially lightened at sea. These arrangements admit of broadsides being fired, when the guns are brought into action, of 1,500lb. in the first instance and 1,800lb. in the second, while both sides of the ship are in a state of defence. The advantages claimed for this system of carrying and fighting guns at sea are:—1. Concentrating the armament of the ship near the centre of gravity and ensuring the chances of the ship's safety at sea. 2. A certain means of working the heaviest guns through the broadside ports of a ship's main deck. 3. Employing shorter, swifter, and more manageable ironclads than at present. 4. Firing a heavier broadside with a smaller crew than at present. 5. A means of giving ships a thicker armour on their sides than can be done with ships compelled as at present to carry their guns always on their broadsides.

Trial of a New Gun.—Some experiments took place on the 14th ult., on the shore at Crosby, near Liverpool, with a large wrought iron gun, made by the Mersey Steel and Iron Company for Mr. Mackay, of Liverpool. The trials were of a preliminary nature, intended to ascertain the general capabilities of the weapon, and to test the velocity of cylindrical shot of various weights with graduated charges of powder. The initial velocity was taken by an electrical apparatus designed by Mr. Newman, of the Electric Telegraph Company, and somewhat similar to that used at Shoeburyness. With a projectile weighing 100lb. and a charge of 20lb. of powder the initial velocity obtained was 1,508ft. per second. Although the wind blew at fitful squalls half a gale across the range, several shots went through the targets, which were placed at distances of 1,000 and 1,500 yards. The weight of the gun is about nine tons, and the bore is 8·12in. diameter. The peculiarity of the system invented by Mr. Mackay is that the shot are plain cylinders, and although the gun is rifled, the projectile has no corresponding adaptation. There is, however, a rotation produced quite sufficient to keep the shot true in its course, as shown by the holes in the targets, which were the exact diameter of the shot.

STEAM SHIPPING.

Steam Shipbuilding on the Clyde.—The paddle steamer, *Washington*, built by Messrs. Scott and Co. for the French Compagnie Générale Transatlantique, has made a satisfactory trial trip. The burden of the *Washington*, which is intended to run between New York and Havre, is 3,400 tons builders' measurement, and her machinery has been supplied by the Greenock Foundry Company, who have fitted her with side lever engines of about 850 horse-power nominal. The diameter of the cylinders is 94½in., and the length of stroke is 9ft. The paddles are 37ft. 6in. in diameter, and the engines are supplied with steam from four large boilers, each fitted with 284 brass tubes, 7ft. long by 3in. diameter. The large boilers are all cased in malleable iron plates, so constructed that any part can be removed without taking down the whole casing. The *Washington* "ran the lights" on her tiral trip in 76½min. The paddle steamer *Lady Bowen*, built by Messrs. A. and J. Inglis for the Queensland Steam Navigation Company, has also made a trial trip, and "run the lights,"—accomplishing the distance between the Cloch and Cumbrae light-houses, in 69min. The *Lady Bowen*, which is 527 tons register, has two oscillating engines of 150 horse-power. Messrs. L. Hill and Co., of Port Glasgow, have launched a screw steamer named the *Jamaica Packet*, for the Jamaica coasting trade, under the agency of Messrs. Jamieson, Souter, and Co., of Kingston. Messrs. W. Denny and Brothers, of Dumbarton, have launched a screw of 872 tons, named the *Tennessee*; she is 872 tons burden, and is to be fitted with engines of 150 horse-power by Messrs. Denny and Co. An armour-plated frigate, intended for the Danish Government, has been launched by Messrs. J. and G. Thomson, of Govan. She is to be fitted with engines of 600 horse-power, and her burden is 3,500 tons, her length being 280ft.; her armour-plates are 4½in. thick, with a strong backing of teak and iron plating.

Trial of the Double Screw Steamer "Atalanta."—On the 16th and 17th ult. the *Atalanta* underwent a trial trip from London to Calais, and thence steamed between that port and Dover against one of the fastest boats of the London, Chatham, and Dover Railway Company. The *Atalanta* is an iron vessel, built by Messrs. J. and W. Dudgeon, Millwall; is 500 tons burden, 200ft. long, 24ft. in breadth, 14ft. in depth, and is driven by two screws, with independent engines, the collective power being 200-horse. On the 16th ult. she left Gravesend at fifteen minutes past twelve, the wind being fresh from E.S.E., and the young flood tide coming up against her. The steam was up for the first time, and it was therefore not intended to make any official trial of her speed between the Thames and Calais, the port to which she was first bound, but in passing the measured mile in Long Reach she was found to be going 14·138 knots. At six p.m. the *Atalanta* was in her berth alongside the pier at Calais, just ahead of the paddle mail packet *Vivid*, with which she was to try her strength across Channel on the following day. The next day the *Atalanta* crossed over from Calais to Dover, so as to steam back from the latter to the former place in company with the *Vivid*, which was appointed to leave with the mail from Dover at 9·30. At forty-five minutes past nine the *Vivid* came out, and the *Atalanta* having been placed in position as nearly as possible abreast of her, the race across commenced. Calais was reached in seventy-seven minutes by the *Atalanta*, but the *Vivid* was 107 minutes—half an hour behind the double screw. The success was of so decided a character that it was considered unnecessary to test the speed of the boat any further, and a return course was therefore shaped for the Thames, where she arrived at five p.m.

The Peninsular and Oriental Company's new Screw Steamship "Baroda" had her official trial a few days since at the measured mile in Stokes Bay. This vessel was built by the Millwall Ironwork's Company, and engined by Messrs. Humphrys and Tennant, of Deptford. Her length between perpendiculars is 295ft.; depth, 26½ft.; breadth of beam, 38ft. She is fitted with vertical direct acting engines, the heating surface of the boilers being 4,820 square feet; fire-grate surface, 180 square feet; condensing surface, 4,247 square feet. Two of the cylinders are 43in., and two 96in. in diameter, with 3ft. length of stroke. Tonnage, builders' measurement, 2,094; registered tonnage, 1,232; gross tonnage, 1,873. A westerly wind was blowing at the time of trial—force 5, increasing to 6, with the barometer at 30.20. The four runs at the measured mile were as follows:—First run, 3min. 56sec., equal to 15·254 knots per hour; steam, 26½; vacuum, 28; revolutions, 78. Second run, 4min. 49sec., or 12·456 knots; steam, 27; vacuum, 28; revolutions, 77½. Third run, 4min., or 15 knots; steam, 27½; vacuum, 28½; revolutions, 78½. Fourth run, 4min. 39sec., or 12·903 knots; steam, 27½; vacuum, 28; revolutions, 77½. The common mean speed was 13·903 knots; the true mean, 13·815. Average of revolutions, 78; steam, 27; vacuum, 28. During the trial the engines, which are 400 horse-power, nominal indicated as high as 2,486. The vessel's draught of water was 17ft. 10in. forward, and 18ft. 3in. aft; total weight of coal, water, &c., on board, 688 tons. The engines in the *Baroda* are the last of six sets built by Messrs. Humphrys and Tennant, exactly identical, for the Peninsular and Oriental Company's steamers, *Mooltan*, *Poonah*, *Rangoon*, *Carnatic*, *Golconda*, and *Baroda*, and another set is now in hand by the same firm for the *China*. The result of the *Baroda's* trial was most satisfactory.

LAUNCHES.

The "Lady Young," paddle steamer has been launched from the yard of Messrs. A. and J. Inglis. She is intended for the Queensland Steam Navigation Company, and her dimensions are as follows:—Length of keel and forerake, 215ft.; beam (moulded) 25ft. 6in.; depth, 12ft.

The "Bolivian," screw steamer, was launched from the yard of Messrs. Robinson and Co., Cork, on the 8th ult. The *Bolivian* is for a Liverpool firm, and is of about 1,800 tons burden.

The Launch of an Armour-clad Frigate for the Danish Government, from the Clydebank shipbuilding yard of Messrs. J. and G. Thomson, at Govan, took place on the 24th February last. She is the same length (280ft.) as the *Hector*, launched on the Clyde in 1862; but otherwise her dimensions are rather less. She is 3,500 tons register, and 500 horse-power, and was designed and built with a view to being used as a "ram," and therefore, instead of having a concealed obtuse beak, like the *Warrior* and *Black Prince*, the whole outline of her bows resembles the curved line formed by a swan's neck and breast. Thus, the projection of the breast is placed about the water line, and would strike the enemy at the water line also. Unlike other recently launched iron-clads, she has an external keel, and also an inner kind of girder which acts as a kelson, and which from stem to stern is formed of immense strength. To this are bolted the massive ribs, which are made in joints, with an angle or ledge on the outer side on which the armour plates, with their thick teak backing, rests. These ribs are unusually close together, thereby adding materially to the strength of the structure. The orlop deck is of wood alone, but the main and upper decks are of iron, the main being covered with thick pitch pine planking, and the upper deck being covered with white pine. All the decks are carried on wrought iron beams of great strength, to which both decks and ribs are rivetted with as much firmness as if the whole were one piece of wrought iron. Her armour plates extend from stem to stern, to a depth of 4ft. below the load line, and are 4½in. in thickness, fastened to the teak backing and inner iron skin in the most approved manner, the whole surface being as smooth as glass. The stem and stern of the vessel are strengthened internally by numerous partitions, and the projecting portion of the prow, which will be exposed to a tremendous strain if the frigate be used as a ram, is secured behind by a network of iron, making this part of the ship exceedingly strong. The screw-propeller is a Griffith's brass one, and the rudder post, which with the sternpost form one casting, is protected by a heavy gun-metal casing. The safety of the pilot and the steering gear has been well cared for, a house of great strength having been built on deck to encase

them. This pilot-house is formed of double iron-plates, with 9in. of teak between, so that no stray shot can do much damage to it. The port-holes, of which there are ten on each side of the main or fighting deck, are of the smallest capacity suitable for warfare, and the height 'tween decks is at least 8ft. The space left for the machinery is all below the water line; and the screw-shaft alley is 6ft. by 4ft., and made of the strongest sheet-iron. Water tanks have already been fitted up hoth fore and aft for trimming the vessel, hy whose means the ship will be kept at a uniform draught, the water being let in or out according as necessity demands. Her engines of 500 horse-power have been made hy the Messrs. Thomson, and will be supplied with steam from four large hoilers. Her armament will consist of twenty broadside guns on the main deck, and 20 guns on the npper deck.

The "Zealous," armour-plated ship, has been successfully launched at Pembroke Dockyard. This is the latest addition to our iron-clad navy. The *Zealous* is 3,716 tons hurthen, and 800 horse-power; she carries 20 guns and has armour-plating 4½in. thick. The thickness of the wooden backing being stated at 8in.

TELEGRAPHIC ENGINEERING.

The Submarine Telegraph Company's half-yearly report states that the receipts for the past half-year, derived from 185,380 messages, amounted to £25,184 1*s.* 2½*d.*; for the half-year ending 30th June, 1863, from 160,404 messages, to £22,144 2*s.* 8½*d.*; and for the half-year ending 31st December, 1862, from 172,881 messages, to £23,427 5*s.* 6½*d.* A dividend at the rate of 4 per cent. per annnm was declared, although the capital has heen largely increased by the issue of new stock. The sum of £2,518 8*s.* 2*d.*, being 10 per cent. on the receipts, was also added to the reserve fund (which now amounts to £6,441 7*s.*) The salaries of the directors were increased from £500 to £1,000.

The Numerous Submarine Telegraph Cables now at work in Europe, are in the aggregate upwards of 5,600 miles long. These cables range from four miles to 1,500 miles each in length, and they are sunk in water varying from 90 to 9,400 feet in depth.

The Telegraphic Communication between Europe and America is about to he carried from New York through British Columbia, to connect the line with that across Behring's Straits, intended to joiu the Russian lines, for the construction of which Mr. Callins, an American citizen, has received a ukase from the Czar. By the completion of these two lines, communication between this country and America will be established without encountering the risks of a submarine cable across the Atlantic.

The Indian Telegraph.—By noon on the 9th of February, 359 miles of the Persian Gulf cable, forming the first section from Gwadur to Cape Mussendom, on the Arabian coast, had been laid from the ships *Kirkham* and *Marian Moore*, and at three o'clock in the afternoon of the same day a telegram, dated Malcolm's Inlet, Mussendom, and sent through the cable to Gwadnr, and thence to Kurrachee, reached Bombay and made known the gratifying news that thus far nothing could have been more successful. The cable is reported to be in perfect working order. The *Tweed*, which is the third of the cable ships, had arrived, and was only waiting for the *Ferose*, to be towed up the Gulf, when the laying of the second section, from Cape Mussendom to Bushire, was to be at once commenced. The *Assage*, with the third section on board, left England nearly five months ago, and has reached her destination, and the probabilities were that by the end of last month, the whole length of the cable would have been submerged, and that Bombay would be in direct telegraphic communication with Bussora. Recent letters from Bagdad, however, make us anxious for the safety of the short land line from Bussora to the city, the Arabs having already, as we learn, hroken the wires and ill-treated the workmen engaged in the construction of the line. Another difficulty likely to make itself felt when the cable has been laid down is the inefficiency of the present telegraph from Kurrachee to Bombay. It will be most vexatious if, after so many serious obstacles have been successfully overcome, telegraphic communication with England is interrupted precisely where it ought to be most safe and regular. The Arabs hetween Bagdad and Bussora may be quieted partly by threats and partly by bribery, but the Indian telegraph department can neither be frightened nor coaxed into doing its work properly, and the sole remedy is for an independent English company to make a line of its own between Bombay and Kurrachee.

RAILWAYS.

New French Locomotives.—At a recent sitting of the Academy of Sciences, M. Combes described a new system of locomotives now in use on the Northern Railway, so constructed as to surmount considerable declivities, and to work on curves of a small radius. These engines have four cylinders and six axletrees, divided into two groups of three each, moved by the pistons of one pair of cylinders. The wheels are so small, that the fireplace of the boiler extends beyond them. In order to facilitate the movement on small curves, a little play is left between the flanges of the wheels which keep the train within the rails, and the rails themselves; moreover, the axles have some play in their sockets. The new engines are said to have mounted gradients of 25 millimetres, and described curves of 80 metres' radius.

French Railways.—M. Béhic, Minister of Public Works, has decided on carrying out some important improvements in the management of railways. A communication must be established between the engineer and the passengers of every railway train within three months, and every railway steam engine must he provided with an apparatus for consuming its smoke within six months. A proposal for increasing the speed of railway trains is likewise under consideration, and is to be carried into execution at the earliest opportunity.

RAILWAY ACCIDENTS.

Accident on the Monmouthshire Railway.—On the 17th ult. the up passenger early train from Newport to Ebbw-vale came into collision with a mineral train, causing injury to five persons. The Western Valleys section of the Monmouthshire has a junction at a place called Aherbeeg, or the double line at this spot is converted into two single lines, the one proceeding up to Nantyglo, on the right side of the mountain, and the other to Ebhw-vale on the left. On the morning in question the signals seem to have been at fault, and the Ebhw-vale train proceeded onwards. It had not gone far before it met the mineral train. The damage done to the engine was extensive, and some of the carriages were shattered.

BOILER EXPLOSIONS.

Boiler Explosion at West Bromwich.—On the 1st ult. an explosion occurred at the ironworks of Mr. Thomas Johnson, sen., by which seven persons were killed and thirteen injured. It appears that Mr. Johnson's works, which are known as the "Old Works," are connected with what are called the "New Works," in the occupation of Johnson and Co. There are ten furnaces in the old works and eleven in the new, together with shopping for millmen, rollers, hundlers, stocktakers, holters-down, &c. There were about 40 men employed at the works in the day-turn, and a similar numher of men in the night-turn. At about a quarter-past three o'clock in the afternoon, after the men had returned from dinner and had recommenced their labour for the remainder of the day, a loud hissing sound was heard, evidently proceeding from the direction of the engine and the machinery, and this was immediately followed by a deafening report. The boiler, a very large one of the kind commonly termed "egg-ended," was situated in about the middle of the premises, and the effect of the explosion was to blow the two sides of the boiler apart nearly at right angles, one part being projected a distance of 60 or 70 yards, into Church-lane, and the other ahout 20 yards in another direction. The remaining portion of the hoiler, and hy far the largest, was hurled almost perpendicularly into the air, and descended not far from the place where it was originally fixed.

Manchester Association for the Prevention of Steam Boiler Explosions.—The last ordinary monthly meeting of the executive committee of this Association—postponed from February 23rd—was held on the 8th ult., when the chief engineer presented his report. This report was double one, embracing the month of January as well as that of February. From January 1st to February 19th inclusive, the ordinary visits of inspection have been made, 2 boilers tested by hydraulic pressure, and 307 defects discovered in the hoilers examined; 10 of which were dangerous. Of some of the defects a few particulars may he given:—Blistered plates.—A blister, measuring 24in. by 12in., and three-sixteenths of an inch in thickness, has been met with inside an internally-fired hoiler, 8ft. in diameter, and working at a pressure of 45lb. on the square inch. Corrosion—Internal. In two boilers, though only 18 months old, the plates, which had been seven-sixteenths of an inch thick originally, were found to be eaten half through, while the rivet heads also were attacked. The plates were honeycombed, being effected more severely at the furnace than at the back end of the boiler. The feed water used was drawn from a well. In another boiler, which was of Lancashire construction, and fed from the Rochdale Canal, the furnace crowns presented a spongy appearance, and channelling had set in at the transverse seams, which is unusual in internal flue tubes; also the rivet heads and angle irons were attacked, as well as the whole boiler generally. Some of the channels were cut half through the plate, while many of the other indentations exceeded this. Internal corrosion has been successfully arrested, in many cases, by the use of carbonate of soda, introduced in small and frequent quantities with the feed water. Corrosion—External. Two waggon boilers were found to be so corroded along the brickwork seating, that holes could he scraped through the plates. Two Lancashire boilers, set upon side walls, though free from leakage at the seams of rivets, were found, on thorough examination, to be seriously corroded at the seating, in consequence of water, arising from the discharge of the safety valves, &c., being allowed to fall upon them. Four case of external corrosion occurred at the bottom of the shells of internally-fired tubular boilers, on account of the unequal expansion of the metal, consequent on the imperfect circulation of the water. The constant straining induced by this unequal expansion had produced leakage at the transverse seams, and thus corroded the plates. In such cases caulking is of little use. In many boilers of this class under inspection, the edge of the overlap has been so repeatedly trimmed and recaulked, that the margin beyond the rivets has been at length all cut away. The only radical cure is to maintain the whole of the shell at an equal temperature, and this, in many cases, has been found to be sufficiently accomplished by carrying a return flue under the bottom of the hoiler. Two other cases arose from the leakage at the tube ends of multitubular boilers, from which the plates at the bottom of the combustion chambers were nearly eaten through. Pressure gauges out of order.—One has been met with which only indicated 14lb. as the blowing-off pressure, while it proved to be as much as 35lb. This shows the importance of all boilers being fitted with suitable taps, in order that the inspector may apply his indicator, so as to ascertain the actual pressure, and check the accuracy of the steam gauge at each of his visits. Explosions:—An explosion occurred on Wednesday, December 30th, 1863. The boiler in question, which was not under the care of this Association, was of plain cylindrical egg-ended construction, and externally-fired. The cause of the explosion was simply neglect on the part of the engine-tenter, who allowed the boiler to get short of water. In consequence of this the plates over the fire became red-hot, and so weakened, that rupture ensued. Though the rent was confined to the bottom of the shell immediately over the fire, the hoiler was blown from its seat and thrown upon the ground, bottom upwards; while another, working alongside, was also dislodged, and thrown to a greater distance than the one that burst. The engine-tenter was prosecuted for neglect, and sentenced to a month's imprisonment with hard labour. Of No. 47 explosion, which occurred on December 31st, 1863, some additional particulars of interest have been obtained since the issue of the last report. The boiler referred to was No. 1 of a series of three, connected together and working side by side, all of them being of plain cylindrical egg-ended construction, and externally-fired. The furnace end was rent into five or six pieces, and the fragments scattered, some of them heing blown to a considerable height, and the remaining portion of the shell was thrown from its original position, and the seating altogether destroyed. From the commencement of the present year up to February 19th, I have to report five explosions, from which fifteen lives have been lost and also twelve persons injured, some of them very severely. Not one of the boilers question was under the charge of this Association. The following is the tabular statement:—

Progressive No. for 1864.	Date.	General Description of Boiler.	Persons Killed.	Persous Injured	Total.
1	Jan. 4.	Balloon or Haystack. Externally-fired	0	0	0
2	Jan. 2.	Plain cylindrical egg-ended. Externally-fired..................	1	0	1
3	Jan. 11.	Boiler for Heating Public Building	0	1	1
4	Feb. 2.	Details not yet fully ascertained.	1	1	2
5	Feb. 17.	Cylindrical, with a single-flue and Bull-dog Ends. Externally-fired.	13	10	23
		Total.....................	15	18	27

No. 1 explosion. The boiler in question worked at a colliery, and was not under the charge of this Association. It was one of a series of two working side by side, both of them heing of balloon or haystack shape, 13ft. in diameter, and having their safety-valves loaded to 14lb. per square inch, although usually the engine worked with steam at a pressure of 5lb. only. The explosion took place on a Monday morning, the boiler and engine having heen at rest on the previous day. The weather was frosty at the time, and the feed pipe, as was found upon examination after the explosion, hecame choked with ice. This cut-off the supply to the hoiler, and it consequently exploded from shortness of water. The boiler was rent into seven pieces, the steam pipes hroken up, a portion of the engine-house thrown down, and the top of the chimney stack damaged. The fragments of the shell and steam pipes, as well as the debris of the building, were scattered to a considerable distance, hut although there were 120 men in the vicinity of the boiler, and many of the flying hricks struck the roof of an adjacent cottage, in which its residents were sleeping at the time, yet happily no one was injured. No. 2 explosion occured to a boiler not under the inspection of this Association, and employed in driving an engine attached to a limestone pit. It appears that the boiler was six years old, and one of a series of two, working side hy side, and connected together, hoth of them heing of plain cylindrical egg-ended construction, and externally-fired. The length of the one in question was 31ft. 8in., the diameter 7ft., and the original thickness of the plates from three-eighths to seven-sixteenths of an inch; while the pressure to which the safety-valve was loaded was 48lb. This, however, would he exceeded whenever the steam blew off at all briskly, and, since there was no steam-gauge, the exact pressure would not be known. Excepting the omis-

sion of the steam-pressure gauge, the boiler was fitted with such mountings as are usual to its class, and might have heen safely worked at a pressure of 50lh. as long as it was in good condition. Such, however, was not the case. Leakage had been going on for some time on the top of the hoiler, both at the seams of the rivets and at the joiut of the feed pipe, which was not rivetted to tbe shell, as it should have heen, but merely bolted. The water from this leakage ran down and corroded both sides of the boiler, though it affected the right hand one more especially, the plates of which it reduced in thickness to nearly one-sixteenth of an inch, for a length of about 8ft. horizontally, just at a part concealed from view by the brickwork in which the boiler was set. At this weakened part, which was below water-line, the shell rent in the first instance, and then tore from end to end, opening out nearly flat and separating into three pieces. All these fragments were thrown from their original position, one of them to a distance of a few feet only, and the other two about 40 yards across a colliery railway. The seating of the boiler was torn up, the engiue house shattered and unroofed, and the dehris scattered in every directiou. It appears that there was plenty of water in the boiler at the time that it hurst, and there is no need for the supposition, that any unusual pressure of steam existed, since the fact of the plates being thinned hy corrosion, as they were found to be, is quite sufficient by itself to account for the explosion. At tbe inquest, tbe owner of the boiler, through his solicitor, attempted to prove the engineman at fault, and to show that the explosion was due to excessive pressure of steam, consequent ou his negligence, and not to the defective condition of the hoiler. Tbe jury, however, returned a verdict of manslaughter against proprietor, as well as the superintending engineer of the works, both of whom it appears had been apprised, more than once, of the leakage which was going on, and their attention called to the necessity of further examination. The verdict of the jury was, however, shortly after set aside on account of informality. No. 3 explosion occurred to a boiler not employed in the generation of steam power, but for heating aud ventilating a public building. This boiler was not under the inspection of this Associatiou. It will be seen hy the date that tbis explosion took place during the severe frost at the commencement of the year; while two other explosions happened to household hoilers, just about the same time, hy which one person was killed and three others injured. It was through the frost that these explosions arose. The water in the pipes froze, and tbus the outlets became choked, and the steam pressure bottled up, so that on the fire being maintained for a sufficient time explosion became inevitable from accumulated pressure. As long as the water in these hoilers retaius its liquid state its own inlet column forms a natural safety valve, but since this action is entirely arrested on the occurrence of frost, every boiler employed for heating and ventilating public buildings, as well as those for household purposes, should he fitted with an efficient mechanical safety valve, which would remain unaffected by changes of temperature. The importance of this with regard to demestic boilers is too apt to be overlooked, but I have known neglect of this precaution to result in fatal consequences in more than one instance. No. 5 explosion was of a very serious character, resulting, not only in considerable damage to property, but also in the death of thirteen persons, and in injury, which in some cases were very severe, to ten otbers. It took place at an ironworks, the boilers of which were not under the cbarge of this Association. The scene of the explosion has been persoually visited, and and the cause investigated, but, since the coroner's inquiry is still pending, tbe publication of the particulars is deferred to the next monthly report.

Boiler Explosion in Spitalfields.—On the 11th ult. a boiler explosion took place at the sawmills and turnery works of Mr. W. Sauders, Slater-street, Spitalfields, which has resulted in the death of the brother of the proprietor aud severe injury to several of the workmen employed. Tbe premises are situated in the quadrangle formed by Farthing-hill, Slater-street, King-street, and Patience-street, and consisted of several wooden and brick buildings, the whole of which have been levelled to the ground by the force of the explosion. At the time of the accideut nearly the whole of the men employed were ahsent at their dinner. Very little is known of the cause of the explosion; the men on the premises at the time can give no definite account of the matter beyond the fact that the explosion took place without the slightest warning.

DOCKS, HARBOURS, BRIDGES, &c.

Milforn Haven.—A company has been formed to raise £220,000 to make locks, floating basin, graving docks, wharfage, jetty piers, &c., at Milford Haven. The vast colliery fields, and the chief towns of Wales, are all connected with Milford by a network of railways, as are also London and the uorth; and very shortly Manchester, too, will be joined by a direct through route. Vessels can sail inwards or outwards whatever the state of the tide might be, and in almost any weather, and the Haven has no bar.

Mallet's Construction of Piers and Walls.—In putting in tbe foundations to walls, piers, and similar structures, it is preferred to make the iron caissons of much greater leugth than has heretofore been usual. The peculiar coffer-dams wbich form part of the subject of this invention are built on the top edges of these caissons as high as may be desired, and are bolted thereto. They are constructed in large sections similar and interchangeable, made of a strong frame of iron covered with metal plates, preferably as those known as Mallet's buckled plates. A continuous double line of watertight coffer-dam is formed, capable of being taken from at one end and added to at the other as the work proceeds. Another part of the invention consists in attaching or mooring floating landing-stages to the shore solely by means of a system of diagonal bracing, forming a framework which is to be hinged to the shore and dummy respectively, thus preventing any horizontal movement of the dummy, while it is allowed free play in a vertical direction for the rise aud fall of the water surface. This system of mooring forms also the support for the approaches.

Accident at the Birkenhaed Docks.—Au accident of a serious nature recently occurred at these docks. The north wall of the Morpeth basin has been for some time in a tottering condition, aud bas had to be supported by piles and backing. In consequence of a portion of the backing having bceu removed, 120ft. of the wall fell in, lifting 50ft. of the heavy structure bodily from the foundations, carrying it 20ft. across the new excavations, and piling it in au upright mass agaiust the splendid granite masonry of the Morpeth lock. The gates of this lock fortunately withstood the shock. To fill the vacuum betwcen the old and new walls, a large quantity of water was necessarily drawn off from the Morpeth basin, and to compensate for the abstraction, a tidal wave of great magnitude rushed up the basin from the river, breaking with great force against the head of the basin, and inundating a portion of the shore road. The whole of the vessels in the Morpeth dock broke their chains and ropes, and some ultimately drifted with the current into the Egerton dock, but generally they sustained only slight damage.

New Iron Bridge at Rhyl.—Messrs. M'Kenzie, Clunes, and Holland, have completed a contract for the construction and erection of a wrought iron lattice bridge, to carry the turnpike road and a tramway across the estuary of the river Clwyd, near Rhyl, North Wales. The ironwork consists of two spans of lattice girders, 81ft. long; one of 76ft. 6in., and a drawbridge opening of 47ft. 6in. in the clear; the whole length of the bridge being 286ft. The girders are 6ft. deep, and width from centre to ceutre 22ft. 6in. The piers are three in number, resting upon 18-in. square timber piles, cased with iron, and capped. The pier columns are composed of patent wrought pile iron, which, when rivetted together, forms a complete column of 18in. external diameter. The ends of the bridge rest upon stone abutments. The roadway or superstructure consists of cross timbers, suspended from the main girders by bolts; the cross timbers are covered by longitudinal planking and iron tramplates for the wheels of vehicles, making a double carriage-way, and leaviug a pathway for foot passengers 4ft. 6in. wide. The drawbridge opens in two halves, and can be opened and closed by two men on each side, in five miuutes. The total weight of wrought iron in tbe bridge is 160 tons, cast iron 56 tons, and 9,748 cubic feet of creosoted timher.

New Bridge at Walton-on-Thames.—The new bridge is on tbe same site as the old one, and has the same number and spans of arches. It has also the same width, 21ft. in the clear; but instead of the steep incline and high summit which were so inconvenient, the approaches are commodious, and the highest point of the roadway in the centre is nearly 20ft. below the old road, though the height and space for navigation are much greater than formerly. This result has been obtained hy the use of wrougbt iron. There are two segmental lattice girders at each side of the bridge, the roadway heing supported by cross girders. There are two spans of 44ft. and two of 62ft., the total lengtb of bridge from shore to shore, including the piers, being 233ft. In addition, a considerahle length of the old flood viaduct was pulled down and lowered, making tbe total length of new roadway and approacbes, included in the contract, about 430ft. The total cost, including the land arches, river bridge, and all the works, was very little over £4,000.

New Pier for St. Ives.—The works of the new pier will be commenced forthwith. Mr. Rohertson has contracted to construct it for £15,500. It will be 600ft. in length, commencing from the Castle Rocks, and is to be completed in August, 1865.

MINES, METALLURGY, &c.

Blasting by Electricity.—A correspondent of *U.S. Railroad and Mining Register*, referring to the puhlished account of the new method of blasting by electricity, invented by a Frenchman, describes that arranged by the engineer corps of the Philadelphia and Reading Railroad Company, and used during the widening of the tunnels at Phœnixville and Manayunk in the year 1859. The hattery consisted of about 25 copper cells, 1ft. long, hy 18in. deep, by 1in. wide, open at top and hottom; tbese were set in a wooden frame, and separated from each other hy common window glass, which was also secured in the frame; inside of each of these cells was a plate of zinc, just large enough to allow a slip of groved wood to hold it away from the copper at the ends. Each zinc plate was connected to the copper cell next to the one in which it was placed, making thus a very large voltaic pile. From each end of this battery an insulated wire ran to the holes to he fired, that from one extremity, of course, goiug from a copper and the other from a zinc plate. The acid used was sulphuric, diluted iu about thirty times its quantity of water. The frame was arranged to raise and lower into a wooden trough or bath, which contained the diluted acid, hy a windlass, so that the person who was engaged in connecting the main wires to those in the holes did his work without any risk of an explosion, the battery not being lowered into tbe acid until he was at a safe distance. For firing the holes two wires were taken and twisted together. At first it was thought necessary that hoth should be insulated, hut it was soon found that if one of them was coated with gutta percha it was sufficient. At the end inserted into the holes these wires were separated about a quarter of an inch, and connected hy a very thin piece of platinum wire; afterwards it was found that steel answered every purpose, aud was much less expensive. This thin wire melted as the charge of electricity passed through it. At the commencement of the work this was inserted directly into the blasting powder, but two great disadvautages arose therefrom—first, the danger of the small wire hecoming broken in tamping the hole; and, second, tbe difficulty of igniting the coarse hlasting powder hy the instantaneous spark of electricity; to avoid both of which a small paper hag, large enough to hold about a gunshot charge, was placed over the end and filled with rifle powder, the hottom heing pasted, shut, and the top tied securely above the steel wire. Another difficulty then arose from the fact that in handling the "cartridges," as they were called, the fine powder was frequently unavoidably shaken out of them. This the men who had charge of loadiug tbe holes soon discovered, and hefore inserting one, would finger the little paper hag to see if it was full, and, as their hands were generally wet, injured the powder. To avoid this, gutta percha was dissolved in ether, and the cartridge dipped into it; as soon as taken out of the mixture the volatile liquid evaporated, leaving a very thin coating of gutta percha over the paper. Thus perfected the "cartridge" was inserted into about the centre of the charge of blasting powder in the hole, tbe opposite ends of the wire protruding, tamping was put in exactly as if fuse were used instead of wires. Before firing, a number of holes were connected together, hy taking the protruding end of one wire of the first hole and twisting it to the end of one of tbe second, the remaiuing one of the second to one of the third, and so on. One of the main wires from the hattery was then connected with the eud of the first wire of this "hatch," and the other to the end of the last; tbe hattery was then immersed in the bath coutaining the acid, and the discharge of the whole lot was instautaneous and simultaneous. As many as twenty holes were frequently fired in one lot. The working of this arrangement was eminently successful. For three months an average of nearly one hundred holes a day were fired at each tunnel without a single accident, so far as the blasting was concerned. This system is almost identical with the oue invented in France. Many of the details, such as coating the bag with gutta percha, &c., will be indicated by local circumstances to practical minds.

The Richest Mine in the World.—It seems that even the enormous profits annually realised from the Devon Great Consols, South Caradou, and other English mines, will henceforth suffice only to secure them a second-class place in the list of the extraordinarily rich mines in existence. The Gould and Curry Silver Miue, in California, yielded £800,000 worth of ore in the seven months ending November last, and £300,000 was distributed to the shareholders in dividends during the same period. The average value of the ores raised is £80 per ton. Ahout 25 tons, worth about £560 per ton, have been shipped to England; nearly 5,000 tons, worth £65 per ton, have been treated at the company's mill, and the remainder has yielded about £11 per ton. The entire cost of raising the ore is 33*s*. per ton, and of reducing it, £8 per ton. The minc is divided into 1,200 "feet" (4,800 shares), and yields £25 per foot per month dividend. The assets of the company amount to £272,000.

GAS SUPPLY.

The Newport Gas Company have declared a dividend of 10 per cent. per annum on Class A shares, and 7½ ou Class B shares.

The Stafford Gas Company have declared a dividend of 7½ per cent. per annum.

The Andover Gas Company have reduced their price 1s. per 1,000ft., or 10 per cent. on previous prices.

The Liverpool United Gas Company have declared their usual dividend of 10 per cent. per annum for the last half-year.

The Winchester Gas Company have reduced their price from 6*s*. to 5*s*.

The Ipswich Gaslight Company have made a further reduction in price from 4*s*. 6*d*. to 4*s*.

The Croydon Gas Company have declared a divideud for the half-year, at the rate of 7½ per cent., with a bonus on the old shares.

The Cuckfield Gas Company have declared a dividend of 5 per cent. per annum.

The Tenterden Gas Company have declared a dividend of 5 per cent. per anuum, and a reserve of £276 for additious and improvements to the works.

The Longton Gas Company's directors recommend the payment of a dividend of 7 per cent.

AT LYNDHURST, some of the inhabitants are anxious to have gas, and several hundred shares have been promised to be subscribed for. It is thought that with a capital of about £3,000 or £4,000, in £2 shares (limited liability), the works would pay from 5 to 7 per cent.

THE WOLVERHAMPTON GAS COMPANY have announced another reduction in the price of gas—from 3*s.* 4*d.* the present maximum price, to 3*s.* per thousand (thirteen candles). The chairman states that this is the sixth reduction made in seven years, and that the total diminution made in the price, since the commencement of 1857, is 2*s.* per thousand cubic feet, or 40 per cent. upon the amount then charged—namely, 5*s.* per thousand.

THE MALMESBURY GAS COMPANY have reduced the price of their gas 10*d.* a thousand. The present price is 6*s.* 8*d.* per thousand, and the contract price of coal 17*s.* 6*d.* per ton.

THE DUDLEY GAS COMPANY have resolved to make a further reduction in the price of their gas.

THE CHARD GAS AND COKE COMPANY have been compelled by threat of a new company to reduce the price of gas from 7*s.* 6*d.* to 6*s.* 6*d.*, and improve it, both in quality and quantity.

THE COCKERMOUTH GASLIGHT COMPANY, in their annual report, states that, in accordance with a resolution passed at the last annual meeting, the price of gas had been reduced to consumers from 5*s.* to 4*s.* 6*d.* per 1,000 feet. The sum of £105 had been expended during the year in laying new mains, &c.; but, after paying all expenses, a balance sufficiently large remained to enable the committee to declare a dividend at the rate of 8 per cent. per annum.

THE SOUTH SHIELDS GAS COMPANY have declared a dividend for the past half-year at the rate of 9 per cent. per annum on paid-up capital. They have also authorised an extension of their works on account of increased consumption of gas.

THE WEST BROMWICH COMMISSIONERS have petitioned Parliament, praying that, in the Act sought for by the Birmingham and Staffordshire Gas Companies, the price of gas topersons consuming less than 25,000ft. per quarter be restricted to 2*s.* 11*d.*; to those consuming over that and less than 100,000ft., 2*s.* 7*d.*; and to those consuming more than 100,000ft., 2*s.* 3*d.*; also that incoming tenants be not liable to pay arrears for gas due by previous occupants, or have their supply stopped on refusal.

AT A MEETING OF THE STOCKPORT COUNCIL, the accounts for the year 1863, presented by the gas committee, were adopted. It appeared that, after paying 5 per cent. to the council on the capital invested in the works, there was a balance left of £3,666 18*s.* 3*d.* This balance, with the interest paid, would be equal to a dividend of about 11·25 per cent. on the invested capital. The quantity of gas produced in the year was 74,086,000 cubic feet, being an increase of 6¼ millions of feet over the year 1862, though considerably under the ordinary quantity of gas produced at the works when all the cotton-mills are working full time. The "leakage," compared with the two or three preceding years, had been reduced to an extent of 7 per cent., which fact, of itself, accounted for a considerable portion of the large balance left in the hands of the gas committee.

APPLIED CHEMISTRY.

ON THE DECOMPOSITION OF IODIDE OF MERCURY, BY H. ROSE.—Iodide of mercury is very easily decomposed by cyanide of potassium. To estimate the mercury in the iodide, the following process may be adopted:—The cyanide of potassium is first rubbed in a mortar with twice its weight of quicklime. A little carbonate of magnesia is then placed in a tube closed at one end; the iodide mixed with eight or ten times its weight of the cyanide, and lime is next introduced; then a layer of the cyanide and lime is added; and lastly, a little carbonate of magnesia is placed on the top; the tube is now drawn out and bent, and the extremity is made to dip into a receiver containing water. Heat is now applied to the mixture, beginning at the top, and the mercury distils over. Other mercuric compounds may be decomposed in the same manner. According to Carius, iodide of mercury is completely decomposed by digestion with nitrate of silver in a not very acid solution. The reaction is definite enough to allow of its being utilised for an estimation. Iodide of silver, like iodide of mercury, is slightly soluble in nitrate of mercury. The red iodide of mercury may be reduced by a solution of protochloride of tin, but the reduction is not complete. With an excess of hydrochloric acid, the reduction is impossible, and the iodide becomes yellow when the mixture is heated. When, however, the mixture is supersaturated with potash, the reduction takes place. Iodide of potassium will also prevent the reduction with protochloride of tin, unless an excess of potash is present. Metallic zinc completely decomposes iodide of mercury in the presence of water, forming iodide of zinc.

NOVEL MODE OF PRODUCING OXYGEN GAS.—At a lecture recently delivered by Dr. Leared, Physician to the Hospital for Consumption, a novel mode of producing oxygen gas in a perfectly safe, cheap, and simple manner, was introduced for the first time in public by Mr. Robins, the analytical chemist. The method consists in treating chromate of potash and peroxide of barium with diluted sulphuric acid. The operation is performed in a common glass jar or retort, and at the ordinary temperature.

NEW USES OF IODINE.—From the specification, recently issued, of a patent by Professor Hofmann, of London, we learn that a new colouring matter, which dyes silk and wool of a beautiful violet, blue violet, or red violet tint, has been produced by the application of iodine extracted from sea-weed. It has long been thought that if iodine could be used as a colouring substance it would be one of the most powerful known. The patented process consists of mixing in certain proportion the substance called rosaniline with the iodides of ethyl, methyl, or amyl. This dye may be used in the same manner as the aniline colours, and is already in the hands of practical people in all the manufacturing districts, and bids fair to be "the colour" of the season. The use of iodine as a disinfector has also been noticed by Dr. Richardson, who states that iodine, placed in a small box with a perforated lid, is a good means of destroying organic poison in rooms. During the late epidemic of small-pox in London he has seen the method used with benefit.

ON THE ADULTERATION OF BEER WITH PICROTOXINE, BY M. SCHMIDT.—In St. Petersburgh, it was found that this berry was used to adulterate certain drinks, but especially beer. Wishing to assure himself of the truth of this statement, M. Schmidt endeavoured to isolate the picrotoxine, and believes he has succeeded by the following rather complicated process:—After evaporating the beer in a water-bath to a syrupy consistence, he mixed it with tepid water till it was perfectly liquid, so as to bring the volume to a third of the liquid used; he then heated and shook it up with animal charcoal. After standing several hours, he filtered, and then heated it slightly, precipitated by basic acetate of lead, and again filtered. The liquid should be of a yellow wine colour; if not, it must be re-filtered through animal charcoal. Then from five to ten cube centimetres of amylic alcohol are to be added to the liquid, which should be briskly shaken several times at intervals. After twenty-four hours, the amylic alcohol collects on the surface, containing the greater part of the picrotoxine. The remainder is subsequently eliminated by fresh treatment with amylic alcohol. Having collected the limpid layers of this alcohol, they are left to evaporate spontaneously. On the sides of the capsule a yellowish ring forms, and this contains the picrotoxine mixed with resinous substances. Such is the first phase of the process; the second, and yet more delicate phase, has for its object the isolation of the picrotoxine. The resinous product is first dissolved in weak alcohol, evaporated to dryness, then recovered by a little boiling water containing a small quantity of sulphuric acid, afterwards boiled to expel any volatile matter, then a little animal black is added to eliminate all extractive and resinous matter; and lastly, it is filtered. The inodorous liquid is next evaporated, and when a fresh bitter taste becomes developed, it is to be shaken up with ether, which re-dissolves the picrotoxine, and collects into a distinct layer on the surface of the liquid. On again treating with ether, the whole of the picrotoxine is eliminated; finally, the etherial liquids are mixed, a little alcohol is added, and the whole is evaporated. The white or yellowish ring formed consists of picrotoxine, which then has only to be dissolved in alcohol to furnish the immediate principle in the form of well-defined crystals. But to obtain these crystals the solution must be free from resinous substances. If not free, and if, for instance, the etherial solution is of a yellow colour, it must be recovered with water, and treated by charcoal, as above described. The latter, it is true, retains traces of picrotoxine, which can be taken up by means of diluted and warm spirits of wine. By these means the author was enabled to detect 0·04 of picrotoxine in a bottle of beer which had been adulterated with eight grains of Indian berry. Picrotoxine has a pronounced bitter flavour; it is in the form of clearly-defined crystals, which form very readily in ordinary alcohol, but not at all in ether or amylic alcohol. If, on the point of a penknife, we take a little picrotoxine, and place it on a highly-coloured plate of glass, then add alcohol to dissolve it, and leave it to evaporate slowly, silky crystals will, after a time, form, and group in tufts; to effect this, the liquid must be sufficiently diluted. Picrotoxine reduces the oxide of copper in Barreswil's liquid. Heated, it forms a yellow transparent mass, resembling caramel, then it becomes charred. Its reaction is neutral; sulphuric acid becomes yellow while dissolving it, and when hot destroys it. Weak sulphuric acid has no action on it, neither have nitric, tartaric, nor acetic acids, when diluted with water, nor ammonia; very soluble in alcohol, ether, amylic alcohol, and chloroform. Slightly soluble in fatty oils and petroleum; hot water dissolves picrotoxine better than cold; and the best crystals are formed in ordinary alcohol.—*Journal de Pharmacie et de Chemie*, xliii, 170. 63.

ON THE PURIFICATION OF SULPHURIC ACID, BY F. MAXWELL LYTE, ESQ.—The best means of obtaining sulphuric acid entirely free from arsenic, fully bear out the fact recorded by MM. Bussy and Buignet, viz., that arsenic, in order to pass during distillation, must be present in the state of arsenious acid. I have, however, been led to employ a different mode of purification, chiefly with a view to ensuring the complete absence of all nitrous products, and obtaining a pure acid from the very first, and of thereby obviating the necessity of changing the receiver—a most dangerous operation when distilling sulphuric acid. If the acid contains nitrous compounds, I heat it in a porcelain capsule to a temperature of about 110° C., with a small portion of oxalic acid, till the latter is completely decomposed, and all effervescence has ceased; about ½ or ⅓ per cent. is amply sufficient for nearly all samples of commercial acid. It is best to add the oxalic acid before heating, and to stir constantly till the reaction is completed. I now allow the acid to cool down to about 100° C., and add to it a solution of bichromate of potassa in sulphuric acid, or some of the salt itself in fine powder, until the pure green colour at first produced by the formation of sesquioxide of chromium is replaced by a yellowish green, indicating an admixture of chromic acid in the free state. The acid so prepared, being now distilled, passes from the first perfectly free from all impurity. The addition of the bichromate has another advantage, viz., that if it be first of all applied to a small sample of the commercial acid, it indicates the presence of free sulphurous acid, as well as of arsenious acid, and either of these being present, we may presume on the absence of nitrous compounds. No doubt permanganates would answer equally well; but the bichromate of potassa, which is cheap and easily procured, is so convenient and in expensive as to leave nothing to be desired.

EASY PREPARATION OF ZINC ETHYL, BY MM. ALEXEYEFF AND F. BEILSTEIN.—The authors employ zinc turnings with only a small quantity of zinc and sodium alloy. Zinc turnings alone do not give a satisfactory result; but on adding a few grammes of the powdered alloy to a mixture of them with iodide of ethyl, the reaction immediately begins, and once established, the turnings are attacked by the iodide of ethyl as easily as the alloy, and the process goes on with the same rapidity. The authors employ the zinc turnings found in commerce, simply dried over sulphuric acid. For 100 grammes of iodide of ethyl they use seven or eight grammes of the alloy and seventy or eighty of zinc. The operation goes on very regularly, and the results are always in accordance with theory.

ELECTRO-CHEMICAL ENGRAVING ON METAL. — A paper, "On a Method of Instantaneous Engraving on Metal," has been read at the Society of Arts, by M. Vial, of Paris. He described various modifications of his discovery, which are patented. In one case, a drawing in metallic ink is laid damp upon a zinc or steel plate, and pressed for two minutes, when the design is transferred to the plate. In another case, an engraving on paper is saturated with a metallic solution, as of copper, and laid upon a zinc plate and pressed, when the copper is precipitated in a few moments over the plate, except where the greasy ink covers the paper. After a farther process positive plates are taken from these negatives by means of printed impressions. A third process consists in drawing on a steel plate with greasy ink, and plunging it into a copper solution, containing a little nitric acid. This also is perfected by a subsequent process. In the discussion on the paper the processes were generally admitted to be of value and importance. M. Vial has had the recognition and thanks of the French Institute.

PROTECTING IRON AND STEEL FROM OXIDATION.—In preparing the hardening or indurating compound for the purposes of the invention of Mr. James Webster, of Birmingham, he takes about equal proportions of carbonate of potash and American ash, pulverised and mixed together, and to this is added hydrochloric acid, until carbonic acid gas ceases to be given off. The proportions in which the carbonate of potash and American ash are mixed are not material; and, in fact, he sometimes uses one or other of the substances without the other, or commercial chloride of potassium may be employed. The mixture, or combination of ingredients above named, is to be put into a close vessel, or retort, and heated so as to drive off the water, and reduce the mass to a homogeneous liquid state, when it is run off, or ladled out, and cast into blocks, which become solid when cold. If chloride of potassium be used, it will only require the addition of a little free acid to render it suitable for the purposes of the invention. Of this mixture, which may be called No. 1, take about 17 per cent., and after roughly pulverising the same, add thereto about 83 per cent. of yellow prussiate of potash, also roughly pulverised; these two ingredients are also melted in a close vessel, and when in a liquid state are fit for use, and may be called No. 2. This mixture may, however, if desired, be cast into blocks for future use, but when required for use must be reduced again to the liquid state. The metal articles to be operated upon are heated to a bright red heat, and in this state are dipped into the liquid or molten preparation, No. 2, after which they are to be left to cool a little, and then dipped in water, where they are to remain until cold. They may cleaned, if desired, and the hardening process will be complete. Many articles, however, require to be protected on their surfaces from oxidation, for which he prepares a varnish composition, consisting principally of (say) 50 per cent. of paraffin oil, nt. pecer fo5 1 naphtha, 3 per cent. of tar, about an equal quantity of mixture No. 2, in a pulverised state, 20 per cent. of resin, and about half that quantity of heavy or tar oil. This preparation will answer very well for rough articles, which must be heated to about 300 deg., and then dipped in the composition. As a modification of the above varnish composition for coating the articles black outside, the following may be advantageously employed:—1½lb. of the composition above named, No. 2, and containing the cyanide of potassium; gutta percha, 4lbs.; creosote, obtained from gas-works, 4lbs.; linseed oil, 50lbs.; and paraffin oil, 40lbs.; also sufficient bisulphide of carbon to dissolve the gutta-percha. For finer articles, the above preparation, with a less quantity of linseed oil, will be found to answer. For steel articles the indurating or hardening process is not required, but the surface of the article may be protected by a similar varnish composition.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

DATED FEBRUARY 23rd, 1864.

451 T. J. Hughes—Sheathing the bottoms of ships or other vessels
452 J. Sanders, jun.—Regulating the pressure of gas
453 J. Howard, J. Bullough, & T. Watson—Warping machines
454 E. A. Cotelle—Concentrating and distilling sulphuric and other acids
455 J. H. Horsfall—Water economiser to be used in connection with fish ladders
456 H. P Delannoy—Power looms
457 A. & F. Izerable—Railway breaks
458 W. Rowan—Steam engines

DATED FEBRUARY 24th, 1864.

459 R Tonge—Looms for weaving
460 A. Wall—Combinations of combustible materials to be used as fuel
461 H. Batt—Clog to be applied to horse shoes as a substitute for roughing
462 L. A. Durrien—Shades for gas lights, lamps, and candles
463 B Jones — Obtaining sulphur from alkali waste
464 E. Ratcliffe & J. Pearson—Temples to be employed in power looms and for stretching woven fabrics
465 F. S. Claxton—Casting iron, brass, or copper over or around hollow cylinders of steel, iron, or other metal
466 J. C. & J. C. Whittenbury, jun.—Convertible desk, church seat, and table
467 C. Esplin—Regulating the flow of gas to burners

DATED FEBRUARY 25th, 1864.

468 W. M. V. Wageneu—Improved boat detaching apparatus
469 B. Burton—Breech-loading and revolving fire-arms and cannon, and metallic cartridges
470 T. Rowatt & A. Lighbody—Lamps for burning paraffin and other oils
471 J. Buckton—Improvements in multiple drilling machines
472 J. F. Rivier—Filtering and purifying liquids with an endless spouting capillary filter
473 A. Jullienne & J. E. de la Combe—Machine to press bricks
474 H. Carter—Manufacture of green colouring matters
475 W. E. Newton—Hoop skirts
476 G. Parry—Treatment of slag or the cinder of blast furnaces

DATED FEBRUARY 26th, 1864.

477 J. H. Johnson—Ploughs
478 E. Calvert—Preparing, spinning, and doubling fibrous materials
479 J. Grantham—Manufacturing compressed fuel
480 C. Hull—Corkscrews
481 C. Shaw—Manufacture of shot
482 A. Prince—Filtering apparatus
483 J. Thornton & J. Higton—Making looped fabrics
484 E. Rolfe—Iron for ironing
485 H. A. Bonneville—Artificial marble

DATED FEBRUARY 27th, 1864.

486 T. Bradford—Apparatus for shaking, riddling, egg-whisking, and mixing, and mortar machines
487 T. C. Barraclough—Boring square or angular-sided holes in wood and other substances
488 W. E. Gedge—Artificial granite, marble, and stone
489 G. B. Braid & R. Furnival—Braided or plaited fabrics
490—F. Ransome—Artificial stone
491 P. H. Muntz—Manufacture of yellow metal sheathing
492 E. C. Shepard—Improvements in breech-loading fire-arms

DATED FEBRUARY 29th, 1864.

493 E. Bingham—Double-action lock for travelling and other bags
494 H. Barwell—Steam generator
495 J. M. Worrall—Preparation of cotton velvets and other fabrics
496 J. P. Worrall—Colouring the back of silk-faced velvets
497 F. Weil—Coating metals
498 J. H. Pepper—Representing spectral and other images on a stage
499 C. Hibberd—Improved memorandum book or diary
500 W. E. Gedge—Hygienic and inodorous apparatus applicable to the cradles or cots of children and to the beds of adult invalids
501 W. E. Gedge—Manufacturing wheat and other grain into flour
502 W. Southam—Improvements in rotary steam engines
503 J. W. Swan—Photography

DATED MARCH 1st, 1864.

504 J. Chapman—Spine bags
505 S. Cooper & J. M. Worrall—Colouring woven fabrics
506 C. G Hill—Bonnet and cap fronts, rouches, and other millinery trimmings
507 W. H. Mellor—Fermenting malt liquors in casks or other like close vessels
508 W. Cox—Roving, spinning, twisting, and winding textile materials
509 T. Rickett—Improvements in steam boilers or generators
510 J. Robinson—Machinery for rolling railroad and other bars
511 W E Newton—Manufacture of velvets or cut pile fabrics
512 J. Woodward—Buffers
513 L. E. Mouline—Atmospheric engine
514 E. Humphrys—Propelling vessels when twin-screw propellers are employed
515 E. T Hughes—Improvements in the manufacture of weaver's harness
516 J. Wild—Propelling vessels

DATED MARCH 2nd, 1864.

517 W. Bunger—Ascertaining the weight of the load supported by the springs of railway locomotives and carriages
518 L A. Laniel—Dressing of vegetable fibrous matters
519 W. Miller—Sugar
520 W. Noton—Opening, scutching, and carding cotton
521 C. P. Raeburn—Production of oil
522 G. Davies—Improvements in breech-loading fire-arms
523 E. F. Pastor—Machinery for burring or charring wool
524 A. V. Newton—Improved construction of percussion pouch
525 J. Pearson—Heating steam boilers
526 M. Barrand & T. O'Keefe—Obtaining motive power
527 G. Gaze Money tills
528 F P. Langenard—Improvements in centrifugal drying machines

DATED MARCH 3rd, 1864.

529 G. H. Ellis Rolling and watering gardens and other kinds of land
530 L. Yvose-Laurent—Application of impervious tissue for manufacturing encampment carpets for the use of the armies
531 W. Wilkinson—Sizing cotton and other warps or threads
532 J. Wright—Oatcake
533 E. H. Bentall—Construction of cutters for facing up wood
534 W. Clark—Treating and utilizing refuse tinned iron and other combined metals
535 H. Bennison — Obtaining motive power by means of water
536 J Crutchett—Winding threads of fibrous material
537 B. P. Stockman & J. S. Scott—Sea and river embankment walls and piers
538 E. Hall — Improvements in machinery for polishing glass
539 S. Pritchett—Improvements in the manufacture of gloves
540 G. T. Bousfield—Improvements in braiding machinery
541 G. P. Harding—Manufacture of tubes, rods, bars, and plates
542 W. Ibotson—Paper

DATED MARCH 4th, 1864.

543 A. Ford—Floor cloth
544 D. Slater — Cabinet furniture and fixtures attached thereto
545 E. T. Hughes—Drying, cooling, and cleaning grain
546 J. Spencer—Apparatus for suspending or holding up sacks and other articles
547 W. E. Newton—Raising and lowering heavy weights
548 F. Lepoutre—Improvements in the machinery of spinning looms
549 R. A. Brooman—Manufacturing green colouring matter
550 M. Henry—Apparatus for propelling
551 S. Bourne—Improvements in casks and other vessels
552 A. Manhre—Glucose sugar
553 F. Smith—Ovens

DATED MARCH 5th, 1864.

554 J. Lockwood & J. Wetherill—Propelling steam ships
555 T. Grace — Improvements in hay making machines
556 H. Cochrane—Improvements in moulds for casting metals
557 L. Hill—Windlasses and riding or mooring bits
558 W. Milligan & B. Duty—Apparatus employed in weaving
559 W. G. Beattie—Improvements in locomotive engines
560 R. A. Brooman—Cloth
561 W. Dangerfield—Bending wood for the handles of walking sticks
562 C. Humfrey — Improvements in vulcanising india rubber
563 T. Gray—Improvements in the treatment of jute and jute cuttings

DATED MARCH 7th, 1864.

564 J. Backhouse—Improvements in machinery for for reaping corn
565 C. Jordan—Improvements in the manufacture of files
566 J. Revell—Oil cans, lamps, or other vessels for lubricating and illuminating purposes
567 A. V. Newton—Heating the feed water of steam boilers
568 W. E. Newton — Improvements in refining sugar and molasses

DATED MARCH 8th, 1864.

569 J. Price & R. E. Donovan—Preventing collisions on railways
570 C E Laederich—Watches
571 W. E. Gedge—Printing on tin or tinned sheet iron
572 W. Moir & C. E. Serjeant—Railways, railway carriages, and telegraphing signals
573 W. Clark—Improvements in water pressure engines
574 J. Lawrence—Signal apparatus applied to steam boilers
575 J. Symes—Pontoons or caissons applicable to building structures in water
576 E. Cowles—Improved sofa or transferable bed
577 H. Greaves — Construction of railways and tramways
578 J. H. Johnson—Improvements in apparatus for drying grain
579 A. V. Newton—Preparation of clay for moulding bricks and other articles
580 W. E. Newton—Improvements in the manufacture of baryta and strontia

DATED MARCH 9th, 1864.

581 L. A. Laniel—Improvements in the solutions of mucilaginous matters
582 F. Tolhausen—Improvements in the manufacture of washing-blues
583 J. M. Worrall—Dyeing looped cut pile or raised fabrics
584 J. P. Worrall—Dyeing looped cut pile or raised fabrics
585 D. Brodie—Heating water by means of waste steam
586 G. Davies—Transforming the ebb and flow of the tide into a continuous and constant hydraulic power
587 C. Brakell—Ginning cotton and other fibrous materials
588 F. Spiers & C. Pond—Improvements in closing or stoppering bottles
589 T. Greenwood & H. Hadley—Dressing silk waste
590 W. Hutchinson—Steam engines
591 R A. Brooman—Balloons
592 E. Bishop & W. Bailey — Evaporating the water contained in fæcal or excrementitious matter
593 W. Clark—Stretching and dressing hides and skins
594 N. Thompson—Stopping bottles, jars, and other vessels
595 J. L. Norton—Manure
596 W. E. Broderick & W. Rees—Needles for sewing machines
597 J. T. Way—Manure
598 G. T. Bousfield—Rollers for spinning wool and cotton
599 S. Blackwell—Breaking horses
600 G. Haseltine—Spring tension regulator

DATED MARCH 10th, 1864.

601 J. H. Schofield—Lubricating frictional surfaces in machinery
602 J. Wallace—Reaping machines
603 T. Boyle—Air and smoke valve
604 T Banks—Improvements in steering ships and vessels
605 J. Claytou—Furnaces for heating and melting iron and steel
606 H. A. Bonneville—Ornamental paper
607 W. W. Burdon—Improvements in hewing or getting coal
608 J. V. N. Bazalgette—Ventilating hats
609 H. E. Clifton—Hot blast ovens
610 J. Shortridge & J. B. Howell—Guns
611 H. N. Penrice—Machinery for tunnelling
612 F. Walton—Raising water

DATED MARCH 11th, 1864.

613 W. Wilson—Supplying hot water to baths
614 F. Wilkinson & W. Rossetter—Carding cotton
615 W. R. Bowditch—Regulating the flow of gas in railway and other carriages
616 W. Cockshott—Driving the spindles of spinning frames
617 C. J. Sharp—Fastening for portemonnaies
618 F. Bessou—Wind musical instruments
619 W. T. W. Jones—Boots
620 F. Foster—Miners' safety lamps

DATED MARCH 12th, 1864.

621 H. Simester & J. Bainbridge—Register stoves
622 J. Taylor—Raising and lowering bodies
623 J. Crompton—Washing, wringing, and mangling machines
624 C. E. Wallis—Revolving fire-arms
625 G. Clark—Guns and projectiles and gun carriages
626 J. & J. Lawson—Weaving
627 R. H. Collyer—Paper
628 E. Walton—Fastening gentlemen's scarfs
629 L. A. Durrieu—Cleaning woollen fabrics
630 W. E. Gedge — Applying and transmitting motive power obtained from the sea
631 A. Smith—Machinery for dragging bristles
632 J. H Johnson—Soap
633 H. Hancock & W. H. Vickers—Fastening for doors, windows, safes, and chests
634 J. Platt & W. Richardson—Pulverising clay
635 R. Fletcher—Varnishing paper hangings
636 T. Rawlings—Wrenches
637 F. H. Needham—Telegraph cables
638 J. Symes—Masts

DATED MARCH 14th, 1864.

639 T. Parkinson, F. Taylor, & T. Burton—Sizing, dressing, dyeing, and drying
640 W. A. Martin & E. Wylam—Furnace bars
641 J. Newey—Fire escape
642 H. Eastwood & B. Matthews—Carding wool,
643 E. Rowing—Steam boilers
644 S. Holmes—Lamps
645 W. E. Gedge—Candles
646 J. Platt & G. Little—Moulding from patterns for casting
647 C. Anderson—Self-acting wire cloth, felt, and endless fabric guides
648 W. Hensman—Raising and lowering weights
649 C. R. Broadbridge—Tables

DATED MARCH 15th, 1864.

650 B. Browne—Machine for mowing grass or reaping grain
651 J. K. Hoyt—Windlasses
652 T. Chamberlayne — Connecting and working railway carriages, trucks, and waggons
653 E. Baller—Gasaliers
654 T. P. Tregaskis—Street railways
655 J. Empson & H. Von Hartz—Rotary engines
656 M. Montgomery—Ships' sounding rods
657 H. Tucker—Scarfs
658 A. N. Saleres—Fixing designs in painted paper hangings
659 A. H Martin—Preparing and spinning wool
660 A. Geber—Applying leather to hats, caps, and bonnets
661 E. F. Ruffin—Marine and land signals
662 J. Rowell—Fences
663 H. Caudwell—Projectiles
664 B Day—Relief plates for printing
665 A. V. Newton—Cupola furnaces

DATED MARCH 16th, 1864.

666 R. Holt—Hoods for ventilators
667 G. H. Openshaw—Power looms
668 J. Carrick—Respirators
669 P. A. Le C. de F. Moreau—Rendering useful the enclosures of railways
670 P. A. Le C de F. Moreau—Fire arms
671 W. S. Longridge—Steam boilers
672 H. Bateman—Rotary steam engines
673 J. Moore & W. Gadd—Pile fabrics
674 R. A. Brooman — Treating vegetable textile matters
675 E. T. Wakefield—Gas lighting and ventilating apparatus
676 J. Laverty—Pens
677 J. Danglish—Aerated bread
678 R. Howarth—Covering railway trucks and other carriages
679 J. Griffiths & J. Jaffrey—Indicating a deficiency of water in cisterns or in boilers
680 W. A. Von Kamp—Railways signals

DATED MARCH 17th, 1864.

681 H. Wood—Weighing machines
682 D. Dalglish—Looms for weaving
683 J. Jarman & S. Sharpe—Steam ploughs
684 J. & J. Horrocks—Spinning cotton and silk
685 J. Bleasdale—Drawing rollers used in machines for preparing and spinning
686 W. Clark—Lubricating apparatus
687 W. Clark—Horse shoes
688 J. Edmondson & T. Ingram—Looms
689 T. Gamble & E. Ellis—Warp fabrics

DATED MARCH 18th, 1864.

690 L. A Durrien—Dyeing fabrics
691 B. Fowler, jun.—Portable drilling machine
692 J. Genevrier and P. E. Bidaux—Spring barrels for clocks
693 F. Dancart—Brakes for railway carriages
694 G. F. Chantrell and J. Reymond—Chimney tops and ventilators
695 F. Tolhausen—Preserving iron
696 J. Burrell—Self-acting scum or brine cock and feed cock
697 J. Swallow—Working the combs used in doffing fibrous materials
698 G. Kershaw—Macerating vessels
699 C. Heywood—Removing particles from the surface of water or other liquids
700 D. Jones—Sugar funnels
701 J. B. Jude—Pressing yeast
702 C. Billson—Woollen shirts and shirt fronts
703 P. J. Rivoulet and C. Lapelouze—Maintaining in a horizontal plane articles on ship board
704 T. J. Searle—Polishing boots and shoes

DATED MARCH 21st, 1864.

705 J. H. Albinson and J. Collier—Spinning, reeling, and weaving
706 W. A. Martin and E. Wylam—Furnace or fire bars
707 H. Steele—Chimney cowls
708 E. Borrows—Pumps
709 A. B. Childs—Circular sawing machines
710 P. Berghaus—Ribbons
711 J. Reilly—Chairs, tables, couches, and sofas
712 F. T. Motson—Cleansing woollen fabrics
713 J. Morgan—Preservation of animal and vegetable substances
714 C. Hill—Boots and shoes
715 H. E. Hutchins—Breech-loading guns
716 G. and C. Firmin—Heating vats

DATED MARCH 22nd, 1864.

717 J. M'Morran—Cutting suet
718 J. Bennie, jun.—Bending or straightening rods, bars, beams, and frames
719 J. and J. Lawson, jun.—Weaving
720 P. Effertz—Bricks, tiles, and pipes
721 J. Leslie—Generating heat
722 G. T. Bousfield—Apparatus used with gun carriages
723 J. Shepherd and J. Hoyle—Raising the nap on woven fabrics
724 S Berrisford and W. Ainsworth—Looms
725 W. Horne—Motive power engines
726 D. H. Barber—Reaping and mowing machines
727 J. Edis—Fastening table tops

DATED MARCH 23rd, 1864.

728 F. L. Roux—Protection of metallic and non-metallic surfaces from the action of water and air
729 H. Desforges and E. C. Sonnet—Gridiron
730 F. Tolhausen—Irons
731 A. Morel—Combing filamentous materials
732 A. Morel—Traction engines
733 W. E. Winby and W. Wharton—Springs for railway and other vehicles

THE ARTIZAN.

No. 17.—Vol. 2.—Third Series.

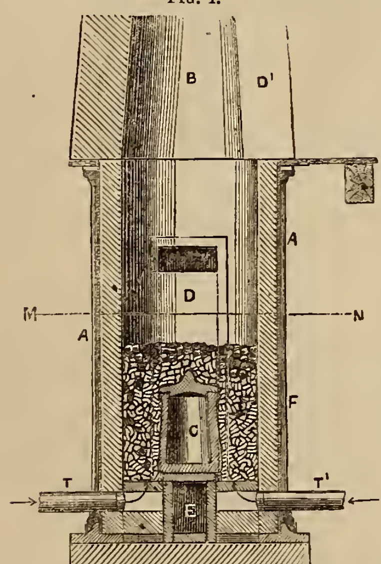
MAY 1st, 1864.

DALIFOL'S IMPROVEMENTS IN THE MANUFACTURE OF MALLEABLE IRON.

The improvements lately introduced by M. T. L. Dalifol, of Paris, as illustrated by the accompanying woodcuts, are deserving of notice, especially at the present time, when so much attention is being devoted to improved processes of iron working. As we have been asked to give a description of M. Dalifol's improvements, we give the following from an account which appears in the *Génie Industriel*:—

The arrangement of the apparatus is shown in the accompanying illustrations. Fig. 1 is a vertical section of a cupola furnace on M. Dalifol's

Fig. 1.



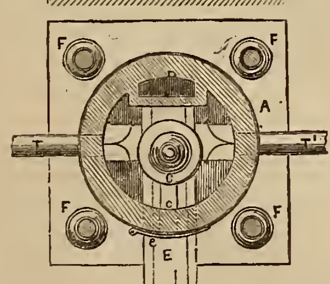
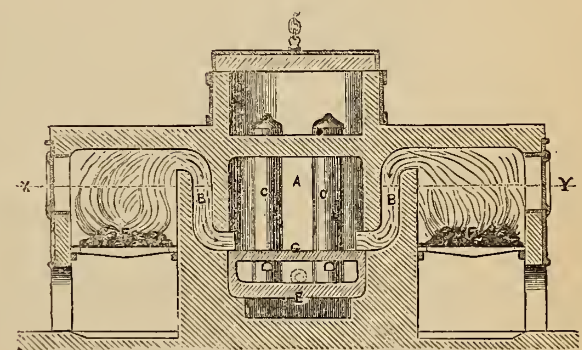


Fig. 2.

plan, Fig. 2 being a horizontal section taken on the line M N Fig. 1. The crucible C, containing the ore, is placed in the centre of the cupola A, the base on which it rests being the top of a flue E. The fuel is deposited in the annular space between the walls of the cupola and the crucible being supplied with air forced through the tuyeres T T. The escaping gases are retained on their way to the chimney by a special flue D, which causes them to descend and pass through a horizontal flue E, leading to the chimney, common to the several furnaces. C is the outlet through which the contents of the crucible are discharged, this outlet being on a level with the door *e*. The crucible is placed in and withdrawn from the cupola through the opening D′ (Fig. 1) in the flue B, above the cylindrical part of the cupola, and which is carried by the four cast iron columns F F.

Figs. 3 and 4 show by a vertical and horizontal section respectively, another arrangement of apparatus according to M. Dalifol's plan—four

Fig. 3.



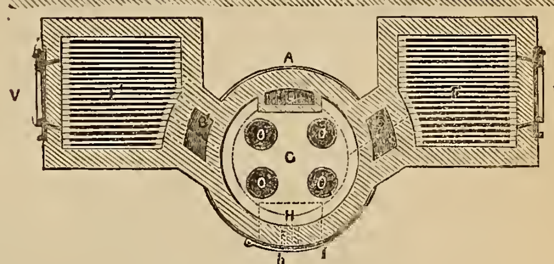


Fig. 4.

crucibles C C being employed and placed in the cylindrical furnace A, which is heated by the two hearths F F′ through the flues B B′ which lead the flame to the level of a plate G, made of fire clay. The flame passes through an aperture H (shown by dotted lines in Fig. 4), and is brought down again through a flue D which heats the bottom plate E on which the crucibles rest; thence it proceeds to the chimney. This bottom plate is made hollow, in order to allow the metal, which flows down from the crucibles, to escape through the small port H. The crucibles are readily placed in the furnace by removing the door I. In both arrangements the crucibles are kept at a very high temperature, the total heat produced is stated to be made useful, and a considerable saving of fuel realised. The crucibles also become less liable to breakage, the temperature in the furnace remaining more uniform during the whole of the operation.

Cail's Shot and Shell and the Recent Trials with Mr. Mackay's Gun.—In The Artizan of last month we gave an account of the trial at Crosby, near Liverpool, of a wrought-iron gun made on a new principle by the Mersey Steel and Iron Works Company, for a Mr. Mackay, of Liverpool. Mr. R. Cail, who entered the lists in 1855 with a novel description of shot and shell, has, since the publication of the trials with Mr. Mackay's gun, again brought forward his system, which is nearly the reverse of that adopted by Mr. Mackay. Mr. Cail proposes to use a *smooth-bore gun and rifled shot or shell* fitting the bore of the gun, all the length of the projectile except the sunk parts forming the rifling. Mr. Cail argues, as the chief advantages of his system, that the gun is not weakened by rifling, and there is no friction between the gun and the shot, and all the power of the explosive gas is used in propelling the shot at the rear, a rotary motion being imparted to it, and that the shot leaves the gun with the greatest initial velocity which the amount of powder burned can give it.

INSTITUTION OF MECHANICAL ENGINEERS.

ON THE CONSTRUCTION OF IRON SHIPS.

By Mr. John Vernon, of Liverpool.

(*Illustrated by Plate* 260.)

The extended and increasing use of Iron Ships at the present day, after the lapse of about thirty years since they were first fairly introduced, renders their construction a subject of importance in a commercial point of view, and of deep interest to all concerned in the development of science as connected with iron structures generally. The application of iron in place of wood to the structure of ships has necessitated a more careful use of the material employed, and a more correct and perfect application of the mechanical principles that are involved in the construction. It is not intended in the present paper to describe novelties of construction in iron ships, so much as to investigate the present systems that are most approved and practised; and when the great difference is considered between a proper and an improper use of the material employed, and the important results that depend upon it, the advantages of such an investigation become evident.

The rapid rate of increase in the application of iron for the construction of ships is strikingly illustrated by the following facts. In the year 1851 there were built and registered in the United Kingdom 55 iron sailing ships and steamers of a gross tonnage of 15,826 tons; while in the year 1862 the number had increased to 219 vessels and 106,497 tons. In the same years the number of vessels built of timber was as follows:—In 1851 there were 617 vessels of a gross tonnage of 133,811 tons, while in 1862 the number of vessels was 740 and the gross tonnage 115,955 tons. It is thus seen that during this period of eleven years there was an increase of 570 per cent. in the tonnage of iron vessels, but a decrease of 13 per cent. in the tonnage of wood vessels; which is the more remarkable from the fact that less than twenty years ago it was considered by many persons of great experience to be a matter of doubt whether iron ships could be adopted at all for general service with any advantage. This doubt, however, was not shared in by many thoughtful mechanical men, who were strongly impressed with the advantages to be obtained from the introduction of iron; and the correctness of their views is now thoroughly established by the practical results that have been obtained on such an extensive scale.

The first consideration in the order of the subject will be the main points of superiority of iron ships over those built of wood. These consist in the superior strength, great durability, and less cost of iron ships, together with their large carrying capability, greater facility of construction, and the more certain supply of the material.

The greater strength of iron ships is shown in daily practice in numerous ways; and it is also shown by the fact that in many modern wood ships it has been found desirable to introduce the use of iron for bulkheads, beams, and stringers, and even for the framework itself of the whole structure. But this arrangement it is considered falls very far short in point of strength of a vessel built entirely of iron; and the only ground upon which such a mixed kind of structure can be advocated is the freedom from fouling possessed by wood vessels when they are coppered, which is an advantage existing in the mixed structure on account of the shell portion being of wood.

The greater comparative durability of iron for the construction of ships arises mainly from its freedom from the decay to which wood is always liable in consequence of its being unavoidably subject to constant and extreme variations of temperature and moisture. Another important source of this great durability is to be found in the firm and substantial union of the several parts of an iron ship by means of rivetting, which effectually prevents that "working" under heavy strains to which all wood ships are more or less liable.

In reference to the question of cost, the comparison in order to be fairly drawn has to be made between the highest class of wood ships as built in this country, with frames of British oak, and the bottom coppered, and the highest class of iron ships. The difference in favour of the latter is in that case about £3 per ton measurement or about 14 per cent.

The larger carrying capability of the iron ship arises first from the reduced weight of the structure, and secondly from the increased internal capacity with the same external dimensions and model as the wood ship. This is shown by the following figures of comparison of a 1,200 ton ship of the two constructions. First as to weight. The wood ship with rigging and all outfit weighs say 18 cwts. per ton measure, equal to 1,080 tons for the whole ship. The iron ship completed in a similar way weighs only say 15 cwts. per ton measure, which would be equal to 900 tons for the whole ship. Hence the 1,200 ton iron ship will carry at the same draft 180 tons additional dead weight of cargo; and this will be equal to 11 per cent addition upon the whole weight of 1,600 tons which is actually carried by a nominal 1,200 ton wood ship; or if no greater weight be carried, the iron vessel will float at 13in. less draft of water. Secondly as to capacity. The wood ship has an internal capacity of 93,343 cubic feet, or at 100ft. per ton 933 tons. The iron ship, because of the reduced thickness of the sides and bottom of the hull, has a capacity of 1,108 tons. Hence in regard to capacity the gain of the iron ship is 175 tons or about 19 per cent. over the wood ship; and there will consequently be space enough to contain the increased weight of 11 per cent. which the iron ship is capable of carrying by reason of its lighter hull.

As to the facility of construction it may be remarked that, instead of a long period being required for preparation and seasoning of the material, as is necessary for a wood ship, the material for the iron ship can on the other hand be used immediately after it is manufactured. Also wood can only be had just as it has grown by nature, and it has to be converted to the purposes required, mostly by hand labour; but the iron can at once be obtained of the precise sizes and forms required, and the use of machinery can be very largely adopted in working it up in the structure of the ship, whereby a great amount of economy can be effected, both in the time occupied and in the cost of labour.

The next point to be considered is the actual strength of an iron ship and its capability of bearing strain; and whether the distribution of material is judicious and efficient, considering the strains to which it is subjected. For this purpose the case will be taken of a ship of 1,200 tons, as shown in side elevation in Figs. 1 and 2, Plate 260, the dimensions of which are 205ft. length, 34½ft. beam, and 23ft. depth of hold; and the ship is supposed to be built to class A 1 at Lloyds' for 12 years or for 20 years with the Liverpool Underwriters' Association, which is considered the best construction at the present day. One half of the transverse section of such ship is shown to a larger scale in Fig. 3, Plate 260, the section of the iron being shown black; and the sectional area of iron is as follows:—

	Fig. 3.	Sq. Ins.
Stringer plates, tie plates, and angle irons on main deck	A	77
Do. do. do. on lower deck	B	55
Sheer strakes	C	61
Sides down to top of bilge	D	298
Turn of bilges and flat of bottom	E	379
Garboard strakes	F	59
Middle keelson	G	42
Sister keelsons	H	43
Bilge keelsons	I	20
Lower hold stringers	K	41
Keel piece	L	26
Total		1101

In the above sectional area the deck planks, amounting to 1,770 square inches, have been excluded from the calculation, because although aiding considerably when in compression they are of very little value for tension; and both cases have to be taken into account.

Taking first the extreme case of strain upon the vessel when supported only at the ends, and allowing 10ft. length at each end for the support, the ship will be as shown in the diagram, Fig. 1, with a length of 185ft. between the supports; in this case the bottom of the vessel is in tension and the top in compression. The displacement of such a vessel at her loaded draft of 20ft. is 2,703 tons, and this weight is made up as follows:—

Iron in hull for 1166 tons measurement, at 10½ cwts. per ton	612	} 758	
Woodwork do. do. at 2½ cwts. per ton	146		
Rigging and outfit	108	} 1945	
Water and general stores	35		
Weight of cargo	1802		
Total			2703

The cargo and other load carried is thus seen to amount to 1,945 tons, which load is unequally distributed over the length of the ship in consequence of the larger capacity in the midships as compared with that at the two ends: and the proportionate distribution as measured from actual sections of an existing ship is shown approximately by the figures marked upon the side elevation, Fig. 1. The length unsupported being divided into six equal portions, the respective cargo capacities or loads of these are in the proportions of 11, 20, 23, 23, 22, 14 respectively, proceeding from the stern to the bows. The result obtained by taking the mean effect of these several loads at the centre of the vessel is that the strain produced at the centre by the distributed load amounts in this case to 74 per cent. of the total load, instead of 50 per cent. or one half the load as would have been the case if the distribution of the load had been uniform throughout the entire length. Hence the total distributed load carried being 1,945 tons, as ascertained above, the equivalent centre load will be in this case 74 per cent. of that amount or 1,440 tons; and the additional weight of the vessel itself, 758 tons, may be considered as equivalent to a load of one half the amount or 379 tons at the centre; making together a total load at the centre of 1,819 tons, one half of which or 909 tons is acting at each end by tension on the lower part of the vessel, with a leverage of 92½ feet, or half the length of the unsupported portion of the vessel.

As the form in which the material is placed in the sectional area of the ship is necessarily determined by the carrying and floating requirements of the ship, and is consequently not free to be arranged in the manner that would simply give the greatest strength as a girder, this case does not admit of satisfactory comparison with a wrought iron box-girder for calculation of the transvere strength. It may be convenient consequently to consider the strains on the whole sectional area as if acting upon a solid girder composed of the material that exists at each point in the depth of the vessel, concentrated into a solid girder of the same sectional area and depth. The diagram, Fig 4, shows the total sectional area of the vessel drawn to double the scale of Fig. 3 in area, or 1-5000th of the actual area of section. The metal is here condensed into the form of a flanged girder for comparison of the areas of resistance in the several portions, in order to deduce an approximate neutral axis for the whole section; and the positions of the several portions of the girder are made to correspond with the exact positions in the general section of the vessel itself, Fig. 3. The sectional areas of iron at the main deck, lower deck, and bottom are 113, 55, and 493 square inches respectively. The top flange of 113 square inches area is made up of the main deck plates and angle irons A of 77 square inches, and 36 square inches of the sheer strakes C from the top M downwards: the bottom flange is taken to include the entire section of iron in the bottom E E of the vessel, from the keel L up to the points O O at turn of bilge on either side, together with the five keelsons G, H H, and I I. The intermediate areas of the sides are 120 square inches between the upper and lower decks, from the sheer strakes C down to the lower deck N; and 320 square inches from the lower deck N down to the point O, at which the bottom is considered to begin: the latter area being divided into two portions of 158 and 162 square inches respectively above and below the neutral axis P. Then these several areas multiplied into their respective vertical distances or leverages give the upper dotted line P P as the approximate neutral axis, about which the moments of the areas above and below are equal; taking the total compression resistance of the upper portion as 5-6ths of tensile resistance of the lower portion, since the ultimate strength per square inch of wrought iron to resist compression is 5-6ths of its strength for tension.

In this case the decks being in compression and the 4 and 3 inch planks of which they are composed being fixed tight and solid together, the timber will contribute materially to the strength of the ship. The resistance of the pine wood to compression may be taken at 3 tons per square inch; and the compression strength of wrought iron being 17 tons per square inch or 5-6ths of its tensile strength of 20 tons, the strength of the wood is about 1-6th that of wrought iron: the value of the timber may therefore be safely taken at 1-8th of the strength of wrought iron per square inch. Hence the sectional area of the main deck planking being 960 square inches, 1-8th of this or 120 square inches has been added in the above calculation to the area of the top flange of the girder in Fig 4, as shown by the outer lines surrounding the shaded portion, making the total area of the top flange 233 square inches. For the lower deck of 810 square inches sectional area, 1-8th of this or 101 square inches has similarly been added, making a total area of 156 square inches.

The neutral axis P thus found is situated 9 feet above the centre line of the bottom portion, Figs. 3 and 4; and the strain tending to produce fracture at the centre of the vessel will therefore be 909 tons $\times\ 92\frac{1}{2} \div 9 = 9{,}343$ tons. Then assuming this strain to be resisted by all the portions in tension in proportion to their respective distances from the neutral axis P, the effective area resisting by tension will be 493 square inches for the bottom portion, and 1-3rd of 162 or 54 square inches for the lower sides; since the centre of gravity of the lower sides, from the neutral axis P down to the point O in Fig. 3, is only a little more than one-third of the way down from the neutral axis P to the centre line of the bottom portion, as seen in Fig. 3. Hence the total effective area resisting tension is 547 square inches, on which the above load of 9,343 tons gives a strain of 17 tons per square inch upon the iron.

This calculation is on the extreme supposition of the vessel being entirely out of the water, and supported only at the two extremities; but practically the vessel when carrying her cargo is supported from end to end by the water, excepting to the extent that this support may be partially withdrawn by the waves and other causes producing an inequality of immersion. It has to be observed that, although the weight of the whole vessel is balanced by its displacement, the extreme ends are very much heavier than their own displacements, and consequently a larger weight is left unsupported at the ends of the vessel while afloat, inasmuch as it throws a strain of compression on the bottom, will to that extent reduce the strain of tension to which the bottom of the vessel is exposed in the case now under consideration, when she is supported at the ends only.

Now considering the opposite case of the vessel being supported only at the centre, as shown in Fig. 2, the strains on the vessel will then be reversed; the top will be in tension and the bottom in compression. In this case the effect of the unequal distribution of the load, taken from the same data as before, will be to produce a strain corresponding to a load at the ends of the vessel amounting to only 44 per cent. of the total load, instead of 50 per cent. or one-half as would have been the case if the load had been uniformly distributed throughout the entire length. The total distributed load carried being 1,945 tons as before, the equivalent load at the ends will in this case be 44 per cent. of that amount, or 856 tons acting at the two ends; and the additional weight of the vessel itself, 758 tons, being taken as before to be equivalent to one-half that amount, or 379 tons at the two ends, these make together a total load at the two ends of 1,235 tons, one-half of which or 617 tons is acting at each end by tension on the upper part of the vessel, with a leverage of half the unsupported length of the vessel or $92\frac{1}{2}$ feet as before.

The neutral axis in this case, found in the same manner as before, but omitting from the calculation the sectional area of the decks which are now in tension, is shown by the lower dotted line Q, Figs. 3 and 4; it is situated at a depth of $16\frac{1}{4}$ feet below the centre of the upper portion, or 21 inches below the previous neutral axis P, thus dividing afresh the 320 square inches area of the lower sides from N to O, Fig. 3, into two portions of 181 and 139 square inches respectively above and below the neutral axis Q, as seen in Fig. 4. The strain tending to produce fracture at the centre of the vessel will therefore be 617 tons $\times\ 92\frac{1}{2} \div 16\frac{1}{4} = 3{,}512$ tons. Then the effective area resisting by tension, found in the same manner as before, will be 113 square inches for the main deck portion, together with $\frac{3}{4}$ of 120 or 90 square inches for the top sides between the decks, $\frac{1}{2}$ of 55 or 27 square inches for the lower deck portion, and $\frac{1}{4}$ of 181 or 45 square inches for the sides below the lower deck; making a total effective area of 275 square inches resisting by tension. Hence the strain produced by the above load of 3,512 tons will be 13 tons per square inch upon the iron.

It may be observed that, although this is an extreme case, it is by no means imaginary as regards the strain which a vessel has to bear continually when floating in the water. For the effect of the imperfect support of the ends of the vessel while afloat, which was previously referred to, is to cause a strain on the transverse area of the midship section similar in action to that caused by the vessel being supported in the middle alone, entirely out of the water, and differing only in degree.

As is well known there are many new plans and improvements in the construction of iron vessels that are partly adopted or in contemplation to be used, which might have been referred to in this paper; but the subject of the paper has been confined to an investigation of the strength and efficiency of iron vessels as generally built of the highest class at the present time. In considering, however, the strength of any new kinds of structures, the same principles are applicable that have been employed in the case now dealt with.

In order to ascertain the comparative strength of iron and wood ships under the two extreme conditions of strain, the same calculation will now be applied to a wood ship of the first class, such as has been previously referred to, and of the same size, 1,200 tons; of which one half of a transverse midship section is shown in Fig. 5, drawn to the same scale as the section of the iron ship in Fig. 3. In Fig. 6 is shown as before, condensed into the form of a solid girder, the area of section of the wood ship, drawn to double the scale in area of Fig. 5, or 1-5000th of the actual area of section. The bottom flange of the girder, Fig. 6, is taken to include all the section of material in the bottom of the vessel, from the keel up to the points R on either side in Fig. 5. The actual areas of each portion of the section are as marked upon the drawing, Fig. 6; namely, 1,011 and 1,074 square inches in the main deck and lower deck portions respectively, exclusive of the decks themselves; 764 square inches in the sides between the upper and lower decks; 1,736 square inches in the lower sides from the lower deck down to the point R where the bottom is considered to begin; and 5,216 square inches in the bottom. In these areas the "ceiling" or lining of the hold, being constructed of 4in. planking secured to the frames of the ship, has been included as acting efficiently both in compression and tension.

When the vessel is supported only at the ends, having the bottom in tension, the main and lower decks, of 944 and 920 square inches area respectively, have to be included in the compression resistance, as in the iron ship; thus the areas of the main and lower deck portions are here increased to 1,955 and 1,994 square inches respectively, as shown by the outer lines surrounding the shaded portion in Fig. 6, in which the neutral axis in this case is shown by the lower dotted line P: it is obtained in the same manner as before in the iron ship, by multiplying the several portions of the sections, Fig. 6, into their respective leverages or vertical distances from the line P, so as to make the moments equal above and below that line; the only difference for the wood ship is that here the ultimate resistance of the timber to compression is taken as $\frac{3}{5}$ths of the resistance to tension. This gives the neutral axis P at $6\frac{3}{4}$ft. above the centre line of the bottom flange of the girder in Fig. 6, dividing the lower sides into two portions of 1,041 and 695 square inches respectively above and below the neutral axis.

The weight of the 1,200 ton wood vessel without cargo is 18 cwts. per ton measure, or 1,080 tons total, as previously stated. Deducting 143 tons for the weight of the rigging, outfit, water, and stores, the same as in the iron vessel, the weight of the hull is 937 tons; half of which, or 468 tons, is therefore taken as the equivalent load at the centre. The internal capacity of the wood ship having been already stated to be only 933 tons as compared with 1,108 tons capacity of the iron ship, the total distributed load of 1,945 tons carried by the iron ship will be reduced in the same proportion, amounting to 1,638 tons: and the equivalent centre load being 74 per cent. of the distributed load, as before, amounts in this case to 1,212 tons. The total centre load is, therefore, 1,680 tons, or 840 tons at each end of the ship, with a leverage of half the unsupported length of the vessel or $92\frac{1}{2}$ft.

Hence the strain tending to produce fracture at the centre of the vessel will be 840 tons $\times$ $92\frac{1}{2} \div 6\frac{3}{4}$ = 11,511 tons tension upon the portions of the section below the neutral axis, Fig 6. The effective area resisting this strain is 5,216 square inches for the bottom portion, and 1-4th of 695 or 174 square inches for the sides below the neutral axis; since the centre of gravity of the sides, from the neutral axis P down to the point R in Fig. 5, is only 1-4th of the way down from the neutral axis P to the centre line of the bottom portion, as seen in Fig. 5. The total effective area resisting tension is therefore 5,390 square inches, on which the above load of 11,511 tons produces a strain of $2\frac{1}{8}$ tons per square inch.

In the opposite case of the vessel supported only at the centre, the top is in tension, and the decks are therefore not included in the resistance. The neutral axis, found as before, is shown by the upper dotted line Q, or which is situated 14ft. below the centre line of the upper portion, Fig. 6, 6in. above the previous neutral axis P; thus dividing afresh the 1,736 square inches area of the lower sides into two portions of 935 and 801 square inches respectively above and below the neutral axis Q, as seen in Fig. 6. The weight of the hull, 937 tons as before is equivalent to half that amount or 468 tons at the two ends; while the distributed load of 1,638 tons in the wood ship is equivalent to 44 per cent. of that amount or 721 tons at the two ends. Hence the total load at the two ends is 1,189 tons, one half of which or 594 tons is acting at each end by tension on the upper part of the vessel, at the leverage of $92\frac{1}{2}$ft. as before.

The strain tending to produce fracture at the centre of the vessel is therefore 594 tons $\times$ $92\frac{1}{2} \div 14$ = 3,925 tons tension upon the portions of the section above the neutral axis Q, Fig. 6. The effective area to resist this strain, found as before, is 1,011 square inches for the main deck portion, together with $\frac{3}{4}$ of 764 or 573 square inches for the top sides between the decks, $\frac{3}{8}$ of 1,074 or 403 square inches for the lower deck portion, and $\frac{1}{7}$ of 935 or 134 square inches for the sides below the lower deck. This gives a total effective area of 2,121 square inches resisting by tension, upon which the above load 3,925 tons produces a strain of $1\frac{7}{8}$ tons per square inch.

Thus if the average tensile strength of all the wood employed in the longitudinal timbers and decks of the ship, namely teak, greenheart, elm, and pine, be taken at 6 tons per square inch in the solid material, and the effective strength be taken at one third of that amount or 2 tons per square inch, in order to allow for the joints, the result obtained is that the greatest possible strain to which it could be exposed, namely in the case of the vessel being supported at the ends only, is $2\frac{1}{8}$ tons per square inch, as above ascertained, or 6 per cent. in excess of the tensible strength of the material: while in the other case of the vessel being supported only at the centre, the strain of $1\frac{7}{8}$ ton per square inch is 6 per cent. less than the strength of the material. In the iron ship, if the tensile strength of the material be taken at 20 tons per square inch, and the effective strength at three-fourths of that amount or 15 tons per square inch, the greatest strain to which it can be exposed, namely 17 tons per square inch in the case of the vessel being supported at the ends, exceeds the strength of the material by 13 per cent.; and in the opposite case of the vessel supported at the centre, the strain of 13 tons per square inch is 13 per cent. less than the strength of the material.

The general result therefore as regards the comparative strength of the iron and wood ships appears to be that in the position causing the greatest possible strain in each case, namely when the ship is supported at the ends only, the strength of the material is deficient for resisting the strain by about one-eighth in the iron ship and one-sixteenth in the wood ship: and in the other position of strain, namely when the ship is supported in the middle, there is an excess of strength in the material of about one-eighth in the iron ship and one-sixteenth in the wood ship. A very important consideration however affecting this comparison of the strength of iron and wood vessels is that the wood vessel selected for the comparison is one of the very first class, as constructed by the first builders in this country; whereas nearly all foreign vessels and most others in this country besides the special few referred to are very much inferior to the one on which the calculations have been founded.

The application of iron for building vessels is peculiarly advantageous in the special class of screw colliers that have recently come into use, with hollow bottoms for carrying water ballast. The traffic in which these vessels are engaged does not usually provide any return freight, and it is obvious a great commercial advantage is obtained by this method of water ballasting for the return voyage, which is accomplished without any delay and with but little cost. Figs. 7 and 8, Plate 260, show transverse and longitudinal sections of an iron screw collier with water ballast, in which it will be seen that a water chamber is formed by the hollow space of the double bottom G G, and a chamber is also obtained in each of the extreme fore and aft compartments H and K, Fig. 8. When the vessel is required to be ballasted, the large sea cocks are opened and water is admitted into the hollow bottom G and the aft compartment K, so as to fill these two portions; and then the water is also admitted into the fore compartment H, to such an extent as may be found necessary for adjusting the draft of water and the due immersion of the screw. When the vessel has arrived in port, the steam pumps are set in action for pumping out the ballast water; or in a dry harbour at low water the large sea cocks are opened, and then the water is easily and quickly got rid of within the short time of the cargo being taken on board; and the vessel is thus got ready for sea again without having experienced any delay on account of discharging ballast. Figs. 7 and 8 represent the iron screw steamer *Annie Vernon*, which is of 518 tons gross register, and 70-horse power. The weight of water ballast contained in the hollow bottom chamber G is 120 tons, in the aft compartment K 20 tons, and in the fore compartment H 30 tons, making a total of 170 tons of water ballast; and the cargo of coal or iron ore which the vessel carries is about 700 tons. The mean draft when in ballast is 8 feet, and when fully loaded with cargo 13 feet, as shown in the transverse section, Fig. 7.

There is, perhaps, no branch of iron shipbuilding in which more special advantages are obtained from the use of iron than in the construction of flat-bottomed boats for river navigation. The extremely small draft of water thereby obtained may be said to be utterly impossible except by the use of iron as the material of construction. An illustration of what is not an unusual specimen of vessels of this class is shown in Figs. 9, 10, and 11, which represent an iron paddle steamer, 226ft. long, 30ft. beam, and 7ft. depth of hold, fitted with engines of 170 horse-power. This steamer draws only about 2ft. of water when light, and can be loaded with coal and cargo to a depth of 4ft.; it maintains a speed of 14 statute miles an hour when steaming alone, and 11 miles an hour with one barge in tow, 200ft. long and 30ft. wide, with 370 tons of cargo on board, having a draft of 4ft. In this construction of vessel two longitudinal iron girders I I are introduced, rising considerably above the level of the deck, in addition to the sides of the vessel being raised as girders to the height of the paddle-boxes, as shown at J J, Fig. 9. The girders I I are required in order to obtain the necessary longitudinal strength as a girder for carrying the weight of the engines and coal, the hull of the vessel being totally insufficient for this on account of its necessary shallowness and lightness. This vessel is made without a keel, as seen in Fig. 9; and with a spoon bow, as shown in Fig. 10. which is found to be a very advantageous form for facilitating getting the vessel off the sand banks that are so frequently met with in such rivers as the Ganges and Indus where these vessels are worked, in which it is found impossible to avoid at times going aground on the sand banks.

A novel system has recently been tried on the Indus for conducting the navigation by means of Bourne's floating steam trains, one of which is shown in Fig. 12. It consists of a paddle steamer L at the head of the train, having a convex stern fitting into the concave bow of the barge M next adjoining; and this barge has a concave stern which receives the convex bow of the second barge N. Other following barges O O, all with convex bows, are fitted together in a similar manner to the second barge, making up a train of five barges with an entire length of 640ft. including the steamer. The connections between the barges are formed by a pair of radial connecting rods with ball-and-socket joints, thus making an articulated train capable of bending into any tortuous line that the navigation of the river may require. This system has not at present answered so well as was expected; the current of the river, both when with the train and when against it, is found to prevent that due control in steering the train which is requisite for keeping it in the winding course desired. The special advantage supposed to be obtained is that of having only one midship section for all the train, instead of one midship section for the steamer and one for each of the five barges; but it will be observed that this advantage, even if assumed to be ever possessed, cannot be realised whenever the train is out of the straight line, since the resisting area will then be necessarily increased in proportion to the curvature of the train.

Fig. 13 shows the area of canvas requisite to drive a first-class merchant ship of 1,200 tons burthen, the size of vessel shown in the previous drawings, Figs. 1, 2, 3, and 5. This is the proportion usually adopted in first-class vessels, giving a total area of 23,313 square feet of canvas. The area of the immersed midship section when laden being 612 square feet,

the proportion thus obtained is 38 square feet of canvas per square foot of section immersed. This proportion is found in general practice with good models of ships to obtain with a good breeze of wind a speed of 12 knots an hour.

The iron used in the framework of iron vessels is applied in various forms of section of single or compound structure. Those which are principally employed are shown in the woodcuts, Figs. 13 to 30, all drawn to one-tenth full size.

For keels, the section shown in Fig 13, is that in most common use as seen at L in Fig. 3, Plate 260. It consists of a plain parallel bar S, Fig 13, about $8\frac{1}{2}$in. deep by 3in. thick for a 1,200 ton ship. This is forged in lengths of about 20ft., and then pieced up by welds into two or three

Fig. 15.

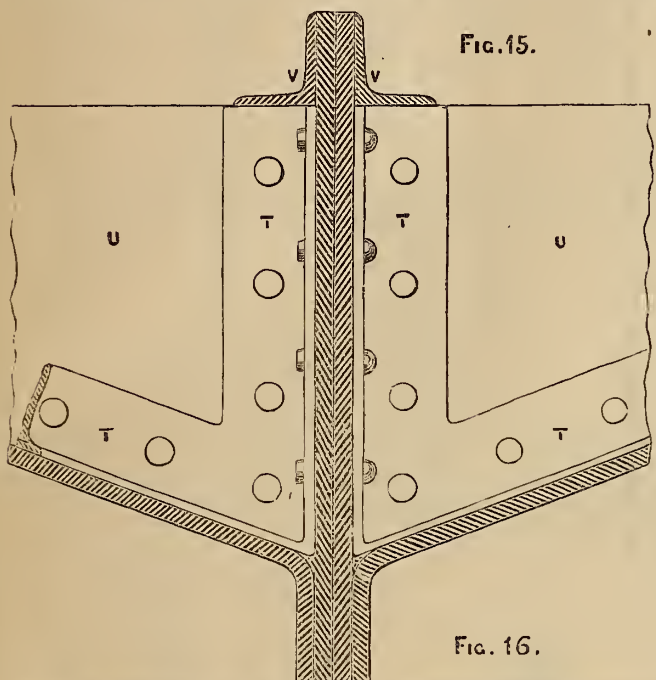


Fig. 16.

Fig. 14.

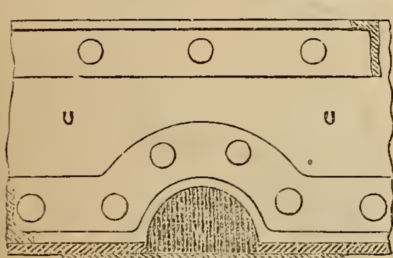
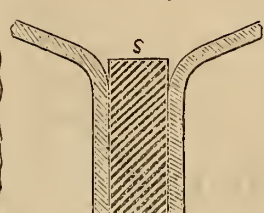


Fig. 13.



lengths for the entire ship, having scarfed joints of a length of eight times the thickness of the keel, which gives room for as many rivets as are required to correspond with the keel. Fig. 15 is a deep keel of plate iron, made by putting two or more plates side by side, breaking joints in every way. The plates are 1 or $1\frac{1}{2}$in. thick and from 3 to 4ft. deep: they are adopted when a forging of the required size would be too large and heavy, say for vessels of 2,000 tons and upwards; and where the scarfing would also be comparatively imperfect. This arrangement is specially adopted in order to be made to serve as a keelson as well. The floor angle iron T T have to be turned up at the foot so as to be rivetted through and through the keel plates; and the floor plates U U are thus made in two pieces, one on side of the keel. The keelson angle irons V V are put on the top of the floor plates and rivetted through and through the top edge of the keel plates. Fig. 16 is the "dished" keel, specially suited to flat bottomed vessels, in which it forms an excellent trough for drawing off the last drop of bilge water. It is made of plates about 1in. thick bent or rolled to the required section. The trough is made of a shape to suit the circumstances, from 6 to 8in. wide and 2 to 4in. deep. Fig. 14 shows an arrangement with a flat plate as a substitute for a keel for flat bottomed vessels, where the draft is limited to the smallest possible amount; and a water course is obtained by an opening W in the bottom edge of the floor plate U and by cranking up the angle iron to correspond.

For keelsons, the section shown in Fig. 17, is that required by Lloyds' rules, and is 2-3rds the depth of the floor plates. Fig. 18 shows the box keelson, seen at G in Fig. 3, Plate 260, which is recommended as superior

Fig. 17.

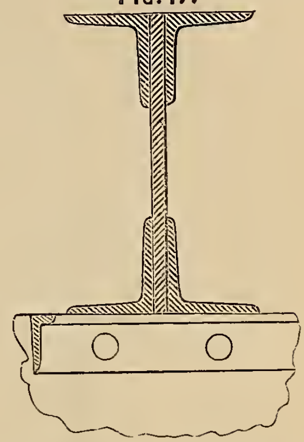
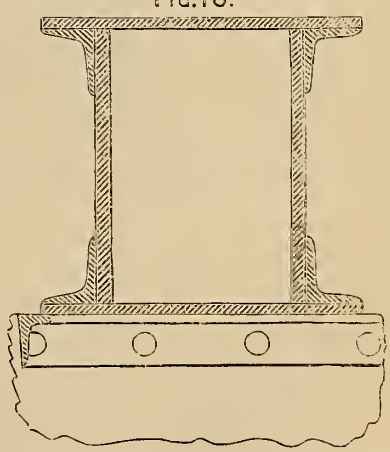


Fig. 18.



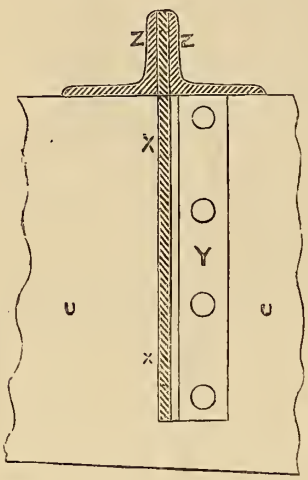
to the preceding, its advantages being the larger section of the top member and the lateral stiffness obtained by the box form. Fig. 19 shows what is called the "intercostal" keelson, seen at H H in Fig. 3, which is of great value in keeping the floor plates in a vertical position so as to retain their best strength. It consists of short pieces of plate X, introduced between the floor plates U and rivetted with angle iron Y to each of them; thus forming a continuous line fore and aft, with double angle irons Z back to back rivetted through the top edge of all the intercostal plates. Fig. 20 shows a box keelson which is intercostal also; this is made either with double intercostal lines of plates X X, as shown in the section; or with a single line only, by one side only of the keelson being let down between the floor plates, instead of both sides.

Figs. 21 to 26 show sections of different forms of stringers. Fig. 21 is a gunwale stringer, such as is usually adopted, as seen at A in Fig. 3, Plate 260. The word "gunwale" is employed to designate the group of iron used along the edge of the main deck at the sheer strake C; and the horizontal flat plate A, Figs. 21, 22, 23, is called the gunwale stringer, and the angle iron B the gunwale angle iron. The size of the gunwale stringer A is 36in. wide by $\frac{3}{8}$in. thick in the midships for a vessel of 1,200 tons. The inner angle iron D is specially valuable as forming an abutment for the edges of the deck planks. Fig. 22 is a box form of gunwale, which has special stiffness and solidity. Fig. 23 shows a form of gunwale with a vertical stringer E, consisting of an inner plate set up on edge; the groove between this stringer and the sheer strake C is made to receive the wood stancheons F for the bulwarks, and between the stancheons the groove is filled up solid with wood. Figs. 24 and 25 are two forms of stringer specially suited for lower hold stringers, or for

any position where they cannot have the advantage of being connected to the end of deck beams. Fig. 25 is seen in position at K in Fig. 3, Plate 260. Fig. 26 is a box form of lower hold stringer suited for similar positions to Figs. 24 and 25, but capable of being made of much greater strength and stiffness.

Figs. 27 to 32 are sections of different forms of deck beams; amongst which may be specially noticed Fig. 28, because with this section the largest amount of strength is obtained with the least amount of material, since the iron is in the form best suited for bearing a superincumbent weight and there is no loss of material by laps of rivetted joints. By the aid of improved machinery this section, Fig. 28, is now rolled to a depth of 16in. and a length of no less than 60ft.

Fig. 19.



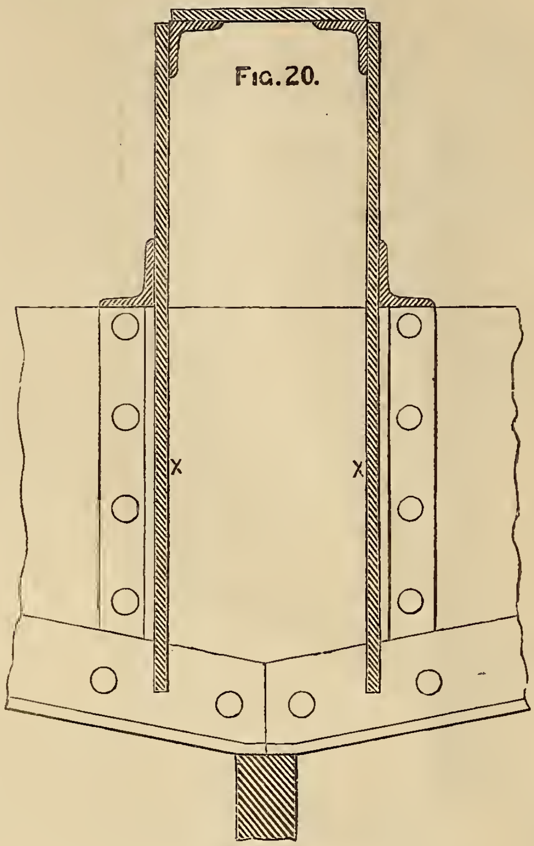
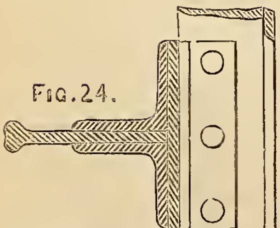


Fig. 20.

Fig. 24.



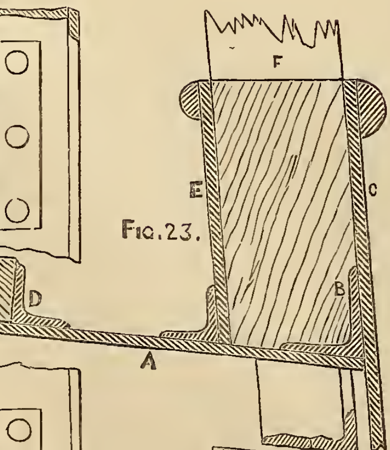


Fig. 23.

Fig. 22.

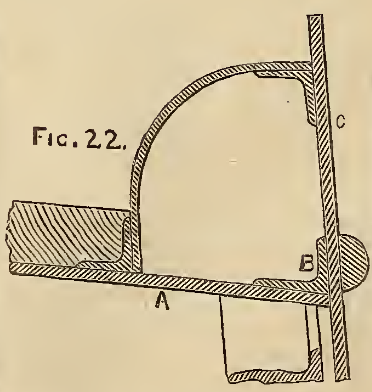


Fig. 26.

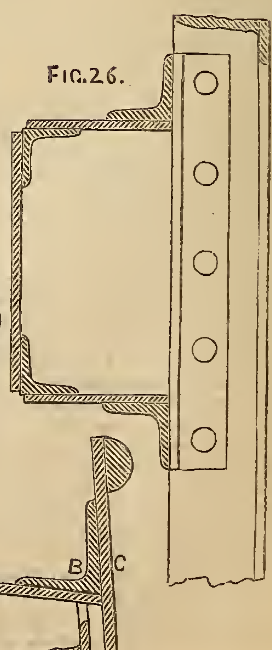
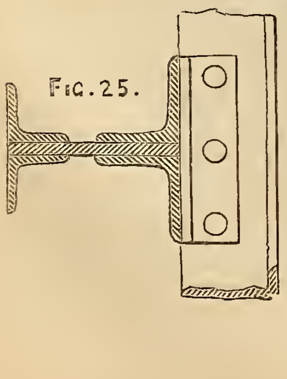


Fig. 25.



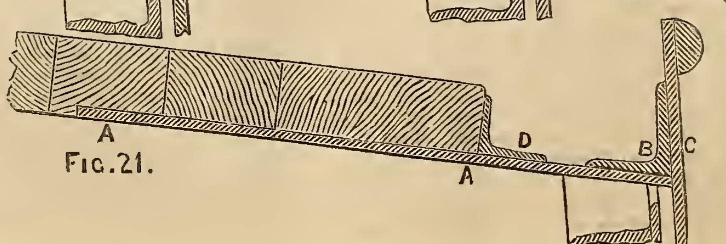
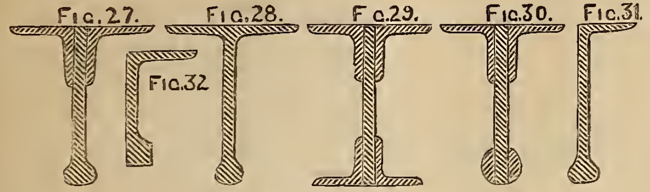
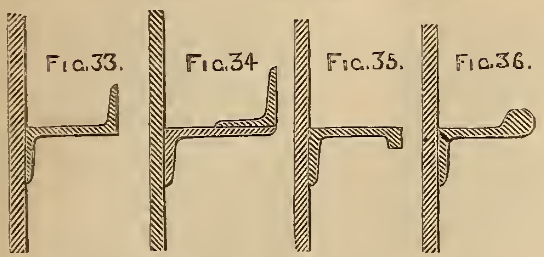


Fig. 21.

Figs. 33, to 36, show sections of different forms of Frame Iron. Of these Fig. 34 is that mostly used; and it possesses the advantage of the reversed angle iron being curved off at the bilges across the bottom of the vessel, to form the top of the floor plates. The three other sections, Figs. 33, 35, and 36 are decidedly better so far as the side frames are concerned,





but are not so well adapted to combine in the formation of the top of the floorings.

The use of iron in the construction of vessels affords great facility for obtaining the necessary strength in keels, stem and stern posts, and screw port frames, &c., by the introduction of large forgings. An illustration of this is afforded by the stern post and screw port frame of the *Great Britain*, 38, 39, and 40, which was introduced in the extensive repairs executed by the writer's firm in Liverpool after the stranding of the ship in Dundrum

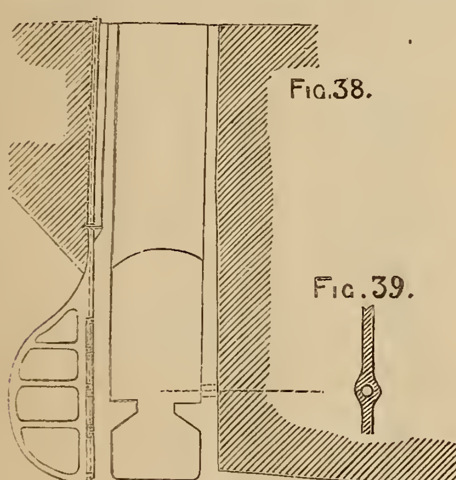
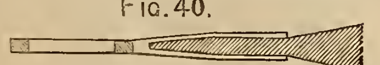


Fig.40.



Bay. The total weight of this framework is about 25 tons: it was put in about the year 1853, and has continued sound and efficient during the constant working of the vessel up to the present time. The *Great Britain* is a good example of the strength and power of resisting damage possessed by iron vessels; for although on the occasion referred to she was stranded for a period of nearly twelve months, and was during that time subject to the severe strains caused by the buffetting of the waves and heavy weather, yet she was ultimately drawn off in safety and was found capable of perfect and efficient repair. The sheer of the vessel along the gunwale was preserved unimpaired throughout, showing the thorough stiffness of the structure as a whole; and although the damage was very serious in amount yet it was entirely local, being mainly confined to large holes and indentations in the bottom of the ship. A wood ship under similar circumstances it is hardly necessary to observe would have had but a small chance of surviving at all.

A question of great importance and interest that has recently arisen in reference to iron ships is, what is the advantage to be obtained by the use of steel in place of iron in their construction. The best steel used for this purpose is guaranteed to bear a tensile strain of 40 tons per square inch, while the best iron will bear only about 20 tons per square inch, or half the strain. This would show that half the weight of steel might be adopted as an equivalent for the iron; but in practice it is not considered advisable to reduce the proportion lower than two thirds the weight of iron. Taking the matter in a mechanical point of view, there can be no objection to the adoption of steel for the purpose so long as it comes up to the professed standard of quality: but considering it commercially, the comparison is as follows, if the price of iron be taken at the average rate of £10 per ton, and the steel at £26 per ton. The iron in the hull of a 1,200 ton ship as before stated is 612 tons, which taken at £10 per ton costs £6,120. Then two thirds that weight of steel or 408 tons at £26 per ton costs £10,608. This shows the weight of the vessel to be reduced 204 tons by the use of steel, and its carrying capability thereby increased to the same extent; but this is obtained at an increased cost of £4,488 as respects the raw material, or at the rate of £22 per ton for the additional weight carried. On the other hand the whole cost of the iron ship of 1,200 tons, taken at £20 per ton is £24,000; and its actual carrying capability being 1,800 tons, its cost is about £13 per ton for the weight carried. It thus appears that the additional 204 tons of cargo would be carried by steel at a cost of £9 per ton more than by the iron bottom; and with this serious additional drawback, that with the steel the increased capability for carrying weight is not accompanied by any corresponding increase in internal capacity, as would have been the case if the additional weight had been carried by proportionately increasing the size of the iron ship at the lower rate of cost.

The above comparison would of course be reduced by risking a smaller proportion of steel, as well as by any reduction in its price. But in order to bring the two ships to an equality as regards total cost, it would be requisite to reduce the weight of steel as low as half the weight of iron and to reduce the price to £20 per ton, when 306 tons of steel would cost £6,120 or the same amount as the iron. In that case the vessel would be able to carry additional cargo equal to the increased difference of weight, namely 306 tons, without additional cost; although without any corresponding increase of capacity for containing this additional cargo.

The mode of rivetting adopted in large first class vessels is principally what is termed "chain rivetting," both in the longitudinal and vertical joints; but in addition to the principal stringer plates, in the upper part of the vessel, and the sheer strakes in the midships, have further rows of rivets with increased lap of the joint plates, making the joints in these cases treble or quadruple rivetted. The relative merits of holes punched or drilled appear to be not so different and not so much in favour of the latter as might be expected: the punched holes are not so regular and so direct through the thickness of the plates as the drilled holes; but notwithstanding this it is found in practice that the punched holes are thoroughly well filled by the rivets, which adapt themselves exactly to all irregularities of holes; the drilled holes though perfectly parallel throughout are not better filled by the rivets than the punched holes, as is seen in the two specimens now exhibited, showing sections of plates rivetted together, one with drilled holes and the other with punched holes. It must be admitted at the same time that the plates are subjected to a somewhat greater strain by being punched than being drilled, though the damaging effect from such a cause cannot be said to be all apparent in the usual execution of good work.

The joints for the plating have now become more perfect than formerly, by the use of the planing machine. The edges of the plates for the butt joints are now planed perfectly straight and smooth, and they are thus brought into contact practice with each other, so as to form a perfectly true and close joint, which could not previously be attained by shearing and the too common practice of hammering up the edges of the plates. All necessity for undue caulking and the use of lining strips is now avoided, and the best strength of the material is imparted to the ship. The quality of iron employed for ship building should in all cases be equal to the tensile strength of at least 20 tons per square inch; and a direct and habitual system of testing should be constantly carried out.

An important point connected with the construction of iron ships is the kind of tools employed and their special adaptation to the purposes for which they are required. Great improvements are constantly being introduced to meet the varied requirements as they arise from time to time, in order to accomplish greater accuracy and perfection of work with increased economy and dispatch. The ordinary tools in general use, such as punching and shearing, drilling, and bending machines, need not be specially referred to here; but attention may be called to some improved machines that have been recently adopted with very considerable advantage. Amongst these may be named a punching and shearing machine, which is fitted

with sliding tables and is self-acting, by the use of which three or more holes can be punched at one time, and each of the four edges of the plates perforated as required with perfect accuracy and truly square with one another; and the shearing also of the four edges of the plates can he made perfectly straight and true, and nearly as smooth as if planed, the smallest width, even down to 1-64th inch, being accurately pared off the edges of the plates. Another machine is a plate-planing machine, hy which the edges of the plates may be planed perfectly true with one or two cuts; thus enabling the workmen to make the most perfect joints with great economy of time and labour. Another machine is a horizontal punching machine, whereby long curved frames may be punched while held in a horizontal position, thus dispensing with the necessary tackle and high roofs necessary if they were to be punched by an ordinary machine, which would require them to be held in a vertical position. The small machine for straightening angle iron by means of pressure from a screw, which is done silently and with perfect effect, is a great improvement upon the old plan of always doing this by the blows of heavy sledge hammers. Another machine, specially useful and productive of economy in the multiple drilling machine, whereby a number of holes, up to twelve or even more, can be drilled at one time in keels, stem and stern posts, &c., with more accuracy of spacing than could possibly he obtained with the ordinary machines which can drill only one hole at a time.

The very extensive use of iron vessels at the present time has now proved that the only objections which can he urged against them are the liability of the bottoms to become foul by the adhesion of animal and vegetable substances, and the derangement of the compasses by the local attraction of the iron in the hull. First as regards the fouling, it has to be observed that the difficulty only exists in the case of vessels engaged on very long voyages, or detained at foreign ports where the water and climate are such as to encourage the growth and accumulation of those substances. This difficulty it must be admitted does exist to some extent with iron ships, and occasionally results in a considerable detention and delay: usually however vessels that are well coated with any of the suitable compositions now so extensively in use, which are destructive to animal and vegetable life are able to prosecute their voyages out and home in almost any part of the world, without ever becoming foul at all, or at least to any extent that is seriously detrimental. The discovery of still better compositions will probably lead almost to the annihilation of this difficulty; and even if they do not effect this, there is no doubt that the graving docks, hoth on land and floating, and the slips that are now being adopted on such a large scale at many important foreign ports will give as great facilities for docking and cleaning the vessels as are possessed in this country, and thus remove the difficulty entirely. Secondly as regards the derangement of the compasses in iron ships by the local attraction of the metal in the hull, this exists in all ships to a greater or less extent, and perhaps there are no two vessels that are exactly alike in this respect. The mode adopted for meeting this difficulty is to neutralise the attraction hy fixing permanent magnets in suitable positions found by a series of trials in each particular ship, the effect of which is to make the compasses nearly correct: the precise amount of incorrectness that still remains is then depicted upon what is called a card of errors for every position of the compasses. This plan affords practically the same results for working the ship as if the action of the compasses themselves were perfectly correct.

An application of iron or steel in place of hemp is now in use in first-class vessels for the standing or fixed rigging, that is those portions that are not what is termed running rigging. The effect of this change in a 1,200 ton ship is that hy adopting iron wire rope in place of hemp a saving in weight is effected of 3 tons, and in cost a saving of £200; and with steel wire rope the saving in weight is 6½ tons over hemp, but without any further saving in cost over the iron wire rope. Greater durability is obtained by the use of wire rope, and damage by moisture is prevented by the wires being galvanised, as well as by covering the wire rope in some cases with a serving of hemp yarn.

The adoption of steel and iron in place of wood for the masts and yards, which is now becoming so extensive, is a subject that requires to be well considered in order to secure the real advantages to he attained hy the change of material, and at the same time to avoid the risks and dangers that would arise from making the change in an injudicious manner. That a saving of weight is effected by this change is shown by the fact that in a 1,200 ton vessel the three lower masts and the bowsprit if made of iron weigh 26 tons, and if made of steel 19 tons, while if made of wood they weigh 32 tons. A corresponding advantage as regards weight is obtained by the use of iron and steel for the topmasts and yards: the weight of the three lower yards if made of iron is 8 tons, and if made of steel 5 tons, while if made of wood their weight is 9 tons. It may therefore be taken as approximately correct that if iron were wholly adopted for the lower masts, topmasts, bowsprit, and principal yards of a 1,200 ton ship, an entire saving of 7 tons would be effected, which saving would be increased to 17 tons if steel were used.

An important point to be noticed in reference to this saving of weight is that it is effected at a position situated at a great height above the centre of gravity of the vessel. Thus in the case of a vessel being light, as for instance during the interval of time between discharging one cargo and taking in another, the saving of 17 tons weight resulting from the use of steel for the masts and yards will take place at a point P, Fig. 37, which is 32ft. above the centre of gravity Q of the vessel in that condition. Hence the centre of the temporary ballast R being 11ft. below the centre of gravity Q, it may be concluded that the result obtained by the saving aloft will he that more than 30 tons of ballast may be dispensed with in the bottom of the hold.

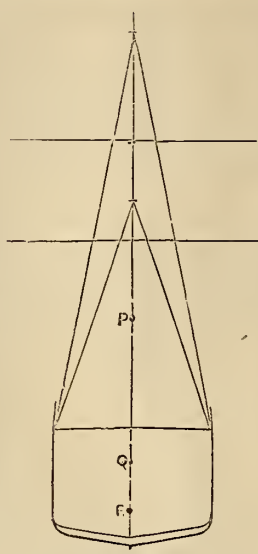


Fig. 37.

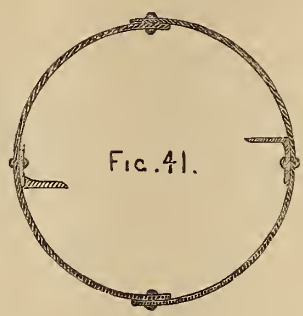
An experiment of some practical interest to show the comparative strength of one of the best pitch pine yards and a cast steel yard of the same dimensions has been carried out at the writer's works, of which the following are the particulars. The yards selected were the actual topsail yards that had been made for a 1,200 ton ship of the same external dimensions, namely 58ft. long, 15in. diameter at the centre, and 7½in. diameter at the ends. For the testing they were carefully bedded upon timber supports 18in. long with 51ft. clear length hetween and were loaded in the centre by actual weights of pig iron in a cradle suspended by chains from a wood saddle 2ft. long, carefully fitted upon the top surface of the yard. In each case the first load included the weight of the cradle and chain.

The successive loads and corresponding deflections of the two yards were as follows:—

1863.	Wood Yard.		Steel Yard.	
	Load.	Deflection.	Load.	Deflection.
	Tons.	Inches.	Tons.	Inches.
23 July	1·29	3·50	1·85	2·25
	1·55	4·00	2·06	2·50
	1·81	4·50	2·35	2·87
	2·08	5·25	2·63	3·19
	2·37	6·00	2·89	3·50
	2·55	6·50	3·10	4·12
	2·83	7·25	3·25	4·50
	2·09	7·75	3·46	4·75
	3·35	8·50	3·60	broken
	3·63	8·87		
	3·91	9·37		
	4·16	9·87		
	4·41	10·25		
	4·65	11·37		
	4·86	11·75		
	5·11	13·00		
	5·38	13·62		
	5·77	16·00		
	6·06	16·50		
	6·41	17·00		
	6·57	17·25		
24 July	6·61	21·50		
	6·85	22·25		
	7·09	23·00		
	7·31	23·75		
	7·52	24·50		
	7·83	25·50		
25 July	7·98	41·00		
	8·04	broken		

The wood yard, of pitch pine, had the load removed on the nights of the 23rd and 24th July, to allow of packing up the ends higher from the ground; and was left unloaded during the whole of those nights. At the end of the second day's testing, at the deflection of 25½in. under 7·83 tons load, the wood began to show signs of fracture on the upper side; but the yard did not finally give way until the load of 8·04 tons was reached. The extreme deflection just hefore hreaking was 41in., heing nearly 1-16th of the yard. The fracture was very perfect in character, the lower side

showing the effects of the tensile strain by longitudinal rents extending for so great a length as 12ft.; and the upper side showing the effects of the compression by the material being crushed up into a lump projecting above the line of the upper side of the yard at each end of the saddle piece; whilst the centre portion for nearly half the diameter, occupying the position of the neutral axis, broke off short and square, as seen in Fig. 43.



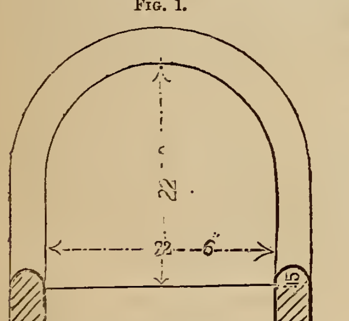
The steel yard, tested on the 22nd July, broke first about 6ft. from one end or 2½ft. from the support; and then on falling it broke at 5ft. from the centre on the opposite side. The first fracture went completely round, and showed on examination a flaw or rather an old crack for almost a fifth of the circumference. The second fracture did not go quite round, but opened about ¼in. on the bottom side. The section of the yard, Fig. 41, was very little altered by the load, and the top showed very little sign of buckling.

The general result of this experiment is that the steel yard broke with a little more than 3½ tons load, and with 4⅝in. deflection; whilst the wood yard required 8 tons to break it, with a deflection of 41in. It is only fair to observe however that in the manufacture of this steel yard some of the plates intended to be used were considered of inferior quality having proved brittle whilst the yard was being made; but these were replaced by good plates at the time so far as they could be discovered.

THE BRADFIELD RESERVOIR.

Our remarks on this subject last month would not be complete if we did not offer any comments on the construction of the by-wash, and on its capabilities of discharging the waters, which, at a given moment, may be collected into the reservoir.

Fig. 1.



Level of top of embankment.

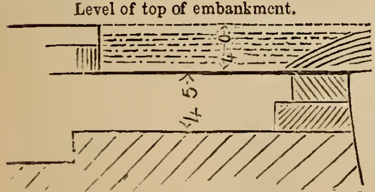


Fig. 2.

The annexed Figs. 1 and 2 show respectively, a plan and section of the weir over which the surplus waters have to discharge themselves into a channel of about 100 square feet in section whose mean slope is about 1 in 10.

Such a channel can discharge, according to D'Aubuisson, a quantity of water given by the following formula

$$Q = 94{,}738\ S\sqrt{\frac{p\ s}{c}}$$

Where Q represents the water in cubic feet per second, S the sectional area of the channel, p the slope, and c the wetted perimeter; and in the present case we find

$$Q = 5000 \text{ cub. ft. nearly.}$$

The quantity of water which the weir can discharge is expressed by the formula

$$Q = \frac{2}{3}\ m\ 8{,}025\ L\ \ H^{\frac{3}{2}}$$

where H is the maximum head upon the weir measured at a point in the reservoir where the water is at rest, L the length of the weir, and M a co-efficient dependent on the thickness and length of the weir. Taking for $\frac{2}{3}\ m$, Mr. Blackwell's value as published in his paper read before the Institution of Civil Engineers in 1852,

$$\frac{2}{3}\ m = 0{,}3 \text{ for a crest 3 feet wide} \times 10 \text{ feet long;}$$

and making H = 3ft. 5in. we find

$$Q = 780 \text{ cub. ft. per second;}$$

but in consequence of the weir being semicircular the flow of the water over it will not take place with the same freedom as if it were rectilinear, and the above quantity will probably have to be reduced by $\frac{2}{10}$, leaving

$$Q = 625 \text{ cub. ft.}$$

It will now be necessary to see what quantity of water will be collected into the reservoir in exceptional cases of heavy rain, and if we take Mr. Gunson's statement as a guide, that the maximum quantity collected per 1,000 acres is 150 cubic feet per second, the area of the gathering ground being about 4,300 acres, we find that the maximum quantity of water collected per second is 645 cubic feet. In order to test the correctness of this statement we have inquired into the extreme cases of rainfall which have occurred at Liverpool during the past two years, and have been favoured with the following data by Mr. J. Hartnup of the Liverpool Observatory, rain-gauge 30ft. above the ground:—

	Hours.		Inches.
1862, May 30th	22	...	2,141
1862, September 3rd and 4th	18	...	1,979
1863, January 1st and 2nd	14	...	1,693
1863, October 30th	9	...	0,957

Since January last, moreover, a rain-gauge has been fixed at 6in. above the ground, and the ratio of the quantity collected in the former, to that collected in the latter, is as 1 to 1·18; if the above quantities, therefore, are increased in this ratio we find that the quantity collected upon an area of 4,300 acres, is as follows in each of the above cases:—

	Cubic feet per Second.
1862, May 30th	499
1862, September 3rd and 4th	563
1863, January 1st and 2nd	619
1863, October 30th	545

From these figures it may be fairly inferred that Mr. Gunson's statement is correct; and it thus appears also that the by-wash, together with the two 18in. pipes (which it has been shown can deliver 100 cubic feet per second), are able to discharge the maximum quantity of water which may be collected into the reservoir when the level of the water therein stands at from 6in. to 12in. below the level of the top of the embankment. This, it must be owned, is rather close work, since any moderate wind would cause a sufficient disturbance to wash the waves over the embankment.

ROYAL INSTITUTION OF GREAT BRITAIN.

ON THE SYNTHESIS OF ORGANIC BODIES.

By J. Alfred Wanklyn, Esq., Professor of Chemistry, London Institution.

On this tray you will see a collection of well-known substances.* Compare these substances with one another, and you will be struck with their dissimilarities. Some are solids and crystalline and brittle, others are liquids which are more fluid than water. Some are without colours; others are highly coloured, and are used for dyeing. Some are sweet, others are bitter; some have delightful perfumes, others have dreadful smells; some are wholesome food, others the most powerful poisons known to man.

In spite of this wonderful diversity in their properties, all the specimens on this tray are compounds of carbon, with a very few elements. Carbon, hydrogen, oxygen, and nitrogen are the only elements which occur in this collection of substances. Some of these substances contain carbon and hydrogen; some contain carbon, hydrogen, and oxygen; some carbon, hydrogen, and nitrogen, and some again contain carbon, hydrogen, oxygen, and nitrogen. But not one of the specimens on this tray contains anything besides these four elements.

There is no difficulty in resolving any one of these substances into its ultimate elements. This sugar,† for example, on being heated to redness in a tube, leaves a black deposit which is carbon, whilst a liquid which is water distils over. If we were to electrolyse this liquid, we should obtain hydrogen and oxygen, and so we should exhibit carbon, hydrogen, and oxygen obtained from sugar. Again, instead of heating this sugar in the tube without allowing the air free access to it, we might burn it in excess of oxygen. If we were to do so, we should obtain carbonic acid and water, and, moreover, all the carbon in the sugar would assume the form of carbonic acid, and all the hydrogen the form of water. So we can obtain carbon and hydrogen, either in the free state, or in the very common and well-known forms of combination as carbonic acid and water. Nitrogen, when it is present, can be made to assume the form of free nitrogen. For that purpose, all that is requisite is to heat the substance to redness with excess of oxygen, and to adopt certain precautions to avoid the production of oxide of nitrogen.

* A tray, with a number of organic bodies lying upon it, was before the speaker.
† Cane sugar was heated to redness in a tube.

Thus, the pulling to pieces of these substances on the tray is a matter of very little difficulty: more than fifty years ago chemists could do that—but how to put the pieces together again is a much more difficult task.

Sugar consists of 72 parts by weight of carbon, 11 parts of hydrogen, and 88 parts of oxygen. We may bring together carbon, hydrogen, and oxygen in these proportions, and shake them up together, or heat them or cool them, and yet we shall never get them to combine so as to form sugar. Alcohol consists of 24 parts of carbon, 6 parts of hydrogen, and 16 parts of oxygen, but no alcohol ever results from making such a mixture. Neither sugar nor alcohol can exist at the temperature to which it is requisite to raise our mixture of carbon, hydrogen, and oxygen, in order to get chemical action to set in. At ordinary temperature the organic elements will not enter into combination, whilst at high temperatures they combine, it is true, but yield comparatively very few compounds.

It was long after chemists had effected the analysis of organic bodies before they learnt how to effect the synthesis of even one of them, and hence the belief sprung up that organic products, such as those on our tray, were intrinsically different from mineral products. Whilst stones, water, and the like were regarded as having their ultimate particles held together by mere dead forces, sugar, alcohol, &c., were regarded as being held together by vital forces, as being in short, in some subordinate way, alive.

Now, no more positive refutation of this notion can be imagined than the artificial construction of substances, in every respect, like those obtained from the animal and vegetable kingdoms, and hence some of the philosophical interest attached to the problem which forms the subject of this discourse.

The first definite example of the construction of an organic body from inorganic materials was given by Wöhler, in 1828, when he made the organic base urea from cyanate of ammonia.

Let us trace the steps of this process. Cyanide of potassium—a body which can exist at a red heat (some cyanide of potassium was exhibited in the form of tabular masses which had been fused), and which can moreover be formed directly from its constituents (carbon, nitrogen, and potassium)—was oxydized by means of peroxide of the manganese at a low red heat, and so cyanate of potash was obtained. The cyanate of potash was next converted into cyanate of ammonia by double decomposition with sulphate of ammonia. Thus cyanate of ammonia was produced from its elements by a process which, although indirect, still did not involve the action of either a plant or an animal. Cyanate of ammonia becomes urea, when its solution in water is simply evaporated to dryness.

It was curious that the first organic body to be constructed should have been a nitrogenous compound.

In 1831, three years after this important discovery of Wöhler's, formic acid—the first term of the fatty acid series—was obtained from inorganic materials by Pelouze. The process was this:—Hydrocyanic acid, a body capable of being obtained from inorganic materials, was heated either with strong alkalis or acids, and was so made to react upon the elements of water as follows:—

$$\overbrace{C\,N\,H}^{\text{Hydrocyanic Acid.}} + 2\,H_2O = N\,H_3 + \overbrace{C\,H_2\,O_2}^{\text{Formic Acid.}}$$

and yielded formic acid.

It does not appear that this research of Pelouze's attracted that attention which it deserved. This we must attribute to the circumstance, that at this period the position of formic acid in the organic series was not recognised.

The next step of importance in organic synthesis was taken by Kolbe in 1845. It was the synthesis of acetic acid, the second term of the fatty series. Kolbe's process was this:—Sulphide of carbon, obtained by the direct combination of carbon with sulphur at a red heat, was submitted to the action of chlorine at a red heat, by which means certain compounds of carbon and chlorine were obtained. One of the compounds, $C_2\,Cl_4$, was then acted upon by chlorine in the presence of water, and tri-chlor-acetic acid resulted.

Having thus got tri-chlor-acetic acid by thoroughly inorganic means, Kolbe availed himself of the observation which had been made of *Melsens*—that treatment of tri-chlor-acetic acid with potassium-amalgam and water converted it into acetic acid.

Kolbe was fully sensible of the scope and importance of his discovery. The following passage occurs in his paper, published in Liebig's "Annalen," for 1845:—"From the foregoing observations we deduce the interesting fact that acetic acid, hitherto known only as a product of the oxidation of organic materials, can be built up by almost direct synthesis from its elements. Sulphide of carbon, chloride of carbon, and chlorine, are the agents which, along with water, accomplish the transformation of carbon into acetic acid. If we could only transform acetic acid into alcohol, and out of the latter could obtain sugar and starch, then we should be enabled to build up these common vegetable principles, by the so-called artificial method, from their most ultimate elements." Thus it appears that Kolbe looked forward to the building up of organic bodies in general, and that he was quite alive to the fact that the synthesis of acetic acid completed the synthesis of the derivations of acetic acid.

Among these derivations may be enumerated acetone, the product of the destructive distillation of acetates; marsh gas, obtained by distilling an acetate with a caustic alkali; ethylene, obtained by Bunsen by heating kakodyl, which itself results by the action of arsenious acid upon an acetate. The electrolysis of acetic acid, which Kolbe accomplished a few years afterwards, yielded methyl and oxide of methyl, which latter, in its turn, could be transformed into any other methylic compound.

Marsh gas was moreover prepared by Regnault, by treating $C\ Cl_4$ with nascent hydrogen; and the common methylic compounds appear to have been produced by Dumas from marsh gas, the chloride of methyl having been obtained by Dumas by the action of chlorine upon marsh gas.

Before 1854, all the foregoing syntheses were fully completed, *i.e.*, there was no step missing between the elements themselves and the most complex compound reached; but, in addition to these complete and definite syntheses, there had also been a good deal of building up of an incomplete or of a less definite character before 1854.

It was known, in a general way, that organic bodies of tolerably simple composition sometimes gave complex products on destructive distillation. Thus, alcohol was known to give naphthaline, benzol, and carbonic acid when it was pressed through a red-hot tube. Formiates were also known to yield hydro-carbons when they were subjected to destructive distillation. The precise dates of these different observations I cannot give, but hand-books of chemistry, published before 1854, contain a statement of the facts.

A few years after 1820—before Wöhler's celebrated Synthesis of Urea, a very remarkable instance of passage from a simpler to a more complex compound was given by Faraday and Hennell. This example is placed along with the indefinite syntheses because it was generally disbelieved in by chemists, and only within the last few years, when it was confirmed by Berthelot, received the general assent. Faraday and Hennell found that olefiant gas was absorbed by sulphuric acid and gave sulpho-vinic acid, from which of course alcohol and the ethers might be procured. Liebig denied what Faraday and Hennell had asserted, and the latter did not insist upon the correctness of their work, and did not take the necessary steps for insuring the reception of their results.

Shortly before 1854, a most capital addition to the art of organic synthesis was borrowed from the doctrine of the Homologous Series. I will endeavour to explain it.

Organic bodies repeat themselves: thus common alcohol has a whole series of representatives, differing from it in formula by $n\ (C\ H_2)$, but resembling it very closely in chemical functions. Alcohol, and these its representatives, constitute a homologous series. Every one of these representatives (homologues) of alcohol possesses a set of ethers and other derivatives, just as common alcohol possesses its ethers and dirivatives. With certain limitations, it is true that whatever reaction can be accomplished in one alcohol can be accomplished with any other alcohol of the series.

Synthesis by series will then be easily understood by an example:—Suppose we obtain a building-up by starting with common alcohol, we should infer that an analagous building-up could be made by starting with any other alcohol of the series.

Here follows a table of the homologous series of alcohols, and of the homologous acids which are related to them:—

Methyl alcohol	$C\ H_4O$	$C\ H_2O_2$	Formic Acid
Ethyl alc.	C_2H_6O	$C_2H_4O_2$	Acetic A.
Propyl alc.	C_3H_8O	$C_3H_6O_2$	Propionic A.
Tetryl alc.	$C_4H_{10}O$	$C_4H_8O_2$	Butyric A.
Amyl alc.	$C_5H_{12}O$	$C_5H_{10}O_2$	Valerianic A.
Hexyl alc.	$C_6H_{14}O$	$C_6H_{12}O_2$	Caproic A.
"	"	"	"
Cetyl alc.	$C_{16}H_{34}O$	$C_{16}H_{32}O_2$	Palmitic
"	"	"	"
Ceryl alc.	$C_{27}H_{56}O$	$C_{27}H_{54}O_2$	Cerotic A.

A good example of synthesis by series was furnished by Frankland and Kolbe, who showed that cyanides of the alcohol-radicles yield the next higher acid in the series when they are digested with an alcoholic solution of potash, thus:

$$\underbrace{\left.\begin{matrix} C\ H_3C\ N \\ +\ 2\ H_2O \end{matrix}\right\}}_{\text{Cyanide of Methyl.}} = \underbrace{\left\{\begin{matrix} C_2H_4O_2 \\ +\ N\ H_3 \end{matrix}\right.}_{\text{Acetic Acid.}}$$

The effect of the alkali is to cause decomposition of water by means of the cyanide, and the reaction very closely resembles Pelouze's, of which mention has already been made.

By means of this synthesis, which is general to the whole series, chemists acquired a method of ascending from any given alcohol to the acid belonging to next higher alcohol. It will be evident, however, that this step, important though it was, did not suffice to enable chemists to march re-

gularly up the ladder. This step from acetic acid to alcohol—from an acid to an alcohol of the same carbon-condensation, was wanting.

This synthesis by series was an incomplete synthesis; there was a gap requiring to be filled up, in order that the regular march might be made up the vinic series.

From the foregoing, it will be seen that by the year 1854 very considerable progress had been made in the building-up of organic bodies from their ultimate elements.

We now pass on to the consideration of the period comprising the last ten years, from 1854 up to the present time.

During this period we have had new methods of accomplishing some of the synthesis which had been effected previously. Thus, formic acid, which had been formed from inorganic materials so long ago as 1831, was built up by Berthelot by means of carbonic oxide and caustic potash,—

$$CO + KHO = CHKO_2$$

and again by Kolbe, by using carbonic acid, moisture, and sodium (the moisture and sodium giving nascent hydrogen),—

$$CO_2 + H + Na = CHNaO_2$$

Again also, the passage from an alcohol to the next higher acid was repeated. Carbonic acid and a compound of an alcohol-radicle with an alkali-metal coalesced, and formed a salt of a fatty acid thus:—

$$CO_2 + \overbrace{Na\,C_2H_5}^{\text{Sodium-ethyl.}} = \overbrace{C_3H_5NaO_2}^{\text{Propionate of Soda.}} \; *$$

* The experiment was shown, and the great evolution of heat which took place on bringing carbonic acid into contact with sodium-ethyl was apparent.

Still these reactions, however interesting they might be, were not new syntheses; they were only new methods of effecting old syntheses.

The great problem, how to step from one alcohol to that next above it, has received a general solution from Mendius. Mendius used cyanogen compounds, those hydrocyanic ethers which had already done such good service to organic synthesis, and exposed them to the higher action of nascent hydrogen, and so obtained amides of alcohol-radicles higher than the alcohol-radicles started from. The reaction bears a close similarity to the one which takes place between the cyanides and alcoholic solution of potash, and which, as will be remembered, enabled us to pass from the alcohol to the acid next above.

Here is a scheme to show the parallel:—

Transformation to Amide.

$$\overset{\text{iv}}{C}\left\{\begin{array}{l} N''' \\ \\ C_2H_5' \end{array}\right. \qquad \overset{\text{iv}}{C}\left\}\begin{array}{l} NH_2' \\ H \\ H \\ C_2H_5 \end{array}\right.$$

Transformation to Acid.

$$\overset{\text{iv}}{C}\left\{\begin{array}{l} N''' \\ \\ C_2H_5' \end{array}\right. \qquad \overset{\text{iv}}{C}\left\}\begin{array}{l} HO \\ O'' \\ C_2H_5' \end{array}\right.$$

In the one case nitrogen is replaced by NH_2 and H, H; and in the other by HO' and O''.

Mendius was able to commence even with hydrocyanic acid. The steps in his synthesis were these:—

Hydrocyanid Acid to Methylamine.

(1) $$CNH + H_4 = CH_3NH_2$$

Methylamine, by means of nitrous acid to methyl-alcohol: methyl-alcohol to cyanide of methyl, well-known processes being employed to effect this:

Cyanide of Methyl to Ethylamine.

(2) $$CNCH_3 + H_4 = C_2H_5NH_2$$

From ethylamine it is easy to get cyanide of ethyl, from which, by a third repetition, we arrive at the propylic stage:—

(3) $$CNC_2H_5 + H_4 = C_3H_7NH_2$$

Thus the vinic series may be ascended; thus there is reason to think we may begin with so simple a body as prussic acid, and step by step proceed from one alcohol to the next above it, until we reach the fats and the waxes. There are other methods of effecting the synthesis of the alcohol series, but none of them seem to be so complete and satisfactory as this:—Berthelot has obtained alcohols by adding the elements of water to the olefines, and some of the olefines he has obtained by the destructive distillation of formiates; but it is an open question—how many olefines can be got by heating the formiates? And, at any rate, there is no precision in the preparation of olefines from formiates.

A very neat and beautiful way of preparing one olefine, viz., common olefiant gas is, however, due to Berthelot. He exposes charcoal to the action of hydrogen at a very high temperature—the temperature of the electric arc, and then union takes place, resulting in the formation of Acetylene:—

$$C_2 + H_2 = C_2H_2$$

Acetylene exposed to the action of nascent hydrogen in an alkaline liquid gives olefiant gas:—

$$C_2H_2 + H_2 = C_2H_4$$

Friedel and Wurtz have converted aldehydes and ketones into alcohol by the action of nascent hydrogen, and hence there arises another method of ascending the vinic series, and besides there are a number of other reactions which are capable of more or less general employment for the purpose of building up the alcoholic series, but which we have not time to particularise.

The alcohols having been got, many other important organic compounds follow, and there is good reason for believing that with the progress of the science all will be derived from them, so that the series of alcohols will constitute a kind of backbone to organic chemistry.

Most modern organic researches are capable of being looked at from a synthetical aspect, for they generally disclose how to devise some organic bodies from compounds which either themselves are, or will be, capable of complete synthesis. Glycerine, the base of the fats, has been derived from the propylic series, having been obtained, by Wurtz, by a somewhat circuitous process from propylene—the olefine of that series.

The sugars have not been, as yet, unequivocally produced, but they will be, for their connection with the hexylic series is now placed beyond a doubt. The production of glycerides from glycerine and fatty acids is the proof that the natural fats are within our grasp. The aromatic series with its many derivations, among which may be mentioned the wonderful aniline dyes which rival those got more immediately from the animal and vegetable kingdoms, becomes accessible to synthesis through common alcohol, which on being heated to redness gives benzol and carbolic acid—members of the aromatic series.

Wurtz's compound ammonias, and above all, the immense and wonderful development of the class of compound ammonias arising from the labours of Hofmann are the pledge that the natural alkaloids—quinine, morphine, strychnine, and their congeners will be one day within our reach.

Glycocoll, produced by Perkin and Duppa from acetic acid, and the bases of the juice of flesh, which have been recently formed by Vollhardt and Hofmann, assures us that albumen—that essential ingredient of our food—will not elude us.

Why should those medicines and foods which we find in nature be the most useful which are possible? Would it not rather be strange if they were?

Hereafter, perhaps, medicines as much more potent than quinine, as quinine is than the extracts of the commonest herb that grows wild, may be the produce of our laboratories.

ON THE QUATERNARY FLINT IMPLEMENTS OF ABBEVILLE, AMIENS, HOXNE, &c., THEIR GEOLOGICAL POSITION AND HISTORY.

By Joseph Prestwich, Esq., F.R.S.

Mr. Prestwich remarked upon the imputation of rashness, and even of credulity, which discoveries such as that of the flint implements often entailed upon geologists. He contended that geologists were, on the contrary, generally disposed to be incredulous. At one time they believed that fishes were no older than the carboniferous strata; that reptiles first appeared during the liassic period; and that mammalia could not be traced beyond the tertiary strata; and it was a long time before they were satisfied that fishes go back to the silurian, reptiles to the carboniferous,* and mammalia to the triassic period. And so with man. Ten years ago there was scarcely a geologist in this country who would not have deemed the occurrence of the works of man in any beds older than the recent alluvium impossible. The discoveries made by Tournal and Christol in the south of France, thirty years since, of the remains of man associated with those of extinct mammalia, were rejected by geologists unanimously; nor were the analogous discoveries of Schmerling in Belgium more favourably received; whilst Frere's remarkable notice, so far back as 1797, of the discovery, at Hoxne, in Suffolk, of flint weapons mixed up with the bones of large extinct animals, was allowed to lie dormant for sixty years.

Even so late as 1855, a communication by the Torquay Natural History Society, respecting the occurrence of worked flints with the fossil bones in Kent's Cave,—a fact already, years before, noticed by the Rev. Mr. M'Enery and by Mr. Godwin-Austen,—was deemed, by the Geological Society, too improbable for publication.

Mr. Prestwich doubted whether, prior to 1858 and 1859, there were twenty men of science in Europe who would have admitted the possibility of the contemporaneity of man and of the extinct mammalia. He instanced Dr. Grant as one of the smaller number who, on abstract principles, treated the question as an open one. He also noticed the tone of confident disbelief with which the asserted occurrence of flint implements in certain geological deposits in the Somme valley was spoken of when he made inquiries respecting this subject in

* Possibly to the old red sandstone.

Paris in 1856 and 1857, and which for a time turned him from the inquiry. Such instances might be multiplied. The speaker did not bring them forward as indicating any perverse opposition, but to show how reluctant geologists were to abandon the belief generally held on this subject without the clearest proofs, and close and careful search on their part. Such, he remarked, is the inevitable progress of all discovery. Facts deemed contradictory to received theory are often long rejected, some as clearly failing in proof, others as non-proven. Evidence is hesitatingly received, and has to force its way through a resisting stratum of incredulity; but, as in the searching resistance offered by close tissues in the separation of mercury from its dross, that portion which passes through issues the brighter and purer the more difficult the transit, and the stronger the pressure exercised.

Allusion was then made to the distinguished palæontologist, Dr. Falconer—one man of science at least in this country with whom the conviction that the remains of man might be traced back to periods greatly antecedent to our ordinary records, had grown, during a long course of years, from probabilities suggested by Eastern research, into certainty established by extensive investigation among the European fossil-bone caves. Referring to his late exploration of Brixham Cave in 1858, the attention which the well-certified discovery of flint implements in undoubted association with the remains of extinct mammalia and of reindeer attracted amongst geologists was remarked upon. The speaker visited the cave in company with Mr. Pengelly, and was much struck with the force of the evidence, though, for various reasons, he considered that cave evidence alone was not sufficient. Urged by Dr. Falconer to go and examine the geological evidence respecting the flint implements in the valley of the Somme, he afterwards paid his long-intended visit to Abbeville (where he, on the very first day, was fortunate enough to find three worked flints at Menchecourt.) He was joined, on the next day, at Amiens, by his friend Mr. John Evans. The geological evidence, and the character of the flint implements, satisfied them both that here again was an undoubted case of contemporaneity of the works of man with the remains of the extinct mammalia. All the author has since seen on many subsequent visits to the Somme valley, sometimes alone, but more frequently in company with other geologists, has tended to confirm his first opinion. He then proceeded to notice some of the phenomena he had seen, and to give his conclusions respecting them. He had intended to have described the several localities in France and England at which flint implements had been found, but found that time would not allow his going beyond Amiens. This was the less important, as Mr. Lubbock had so recently given an able account in the same room of most of these places; and his auditors were probably most of them acquainted with the more general account given by Sir Charles Lyell in his recent work on the "Antiquity of Man."

Mr. Prestwich then went on to describe the remarkable discovery of M. Boucher de Perthes, and how much honour and credit were due to him for his untiring perseverance, in face of general discouragement, for a period of twenty years, and for twelve years after the publication of his elaborate work, "Antiquités Celtiques et Antédiluviennes." Incited by this work, Dr. Rigollot, an antiquary of Amiens, discovered flint implements in great numbers near that town; but his careful memoir on the subject, although it attracted the momentary attention of some French geologists, was allowed to drop comparatively unnoticed. Geologists admitted the antiquity of the beds, and antiquaries admitted the workmanship of the implements; but neither would own to a conjoint interest and belief in them.

Before entering upon the details of the sections, Mr. Prestwich proceeded to make a few remarks upon the conditions under which the flint-implement-bearing beds were found, and how their importance and the time they represent were to be judged of. He observed that sea-formed deposits afforded massive and tangible monuments of the length of time required for their accumulation. But on land, time passes, and builds no such monuments of its duration. The sand and shingle beds of a rapid river would be little, if at all, thicker now than a thousand years ago, for, instead of accumulating in the channel of that river, they are incessantly removed, and carried eventually out to sea, where they contribute to the formation of the great sedimentary deposits constantly going on there. The time represented by river deposits (apart from the recent silty alluvia) is not therefore to be measured by their thickness; and we must not attach the less importance to the beds containing the flint implements, because, being formed by river action, they are necessarily small, fragmentary, and superficial. But while in the sea the accumulation of matter has formed a relative measure of time, on land the extent of denudation resulting from the removal of a portion of that matter supplies an obverse scale. In the former case the lapse of time is chronicled by constantly accruing deposits, whereas in the latter case the deposits cannot exceed a certain thickness. They are constant quantities, and their dimensions are no measure of their age. The only test of their age consists in their organic remains, and in the depth of the valleys below the terraces on which portions of them are lodged. In speaking of river action, the author does not refer to the slow and sluggish streams of this country, but to the more active streams of countries of greater rainfall, or to old conditions of ormer periods.

Mr. Prestwich then proceeded to refer to a large pictorial section of the celebrated pit at St. Acheul, near Amiens. The artist had not visited Amiens, but had skilfully contrived to give a sufficiently accurate representation of the town and valley, for the purpose of showing the general relation which the ground there bore to the surrounding district. The details of the pit were, however, all given from actual survey by the speaker. The surface of the ground at the pit is 100ft. above the level of the Somme, which flows in the valley at the foot of the hill. The valley itself is about one mile broad. The hills on either side, rising to a height of 200 or 300ft., consist of chalk, with a few and distant cappings of tertiary strata.

On platforms of various breadths, generally on the top of low hills adjoining the valley, patches of gravel occur at intervals more or less long from the lower to the upper end of the valley, whilst a more connected series of gravel beds skirts the base of the valley. The chief portion of the valley is, however, occupied by alluvial beds, beneath which the last-mentioned gravels with their brick-earth, pass.

The higher level gravels rarely contain organic remains. The pit at St. Acheul affords a singularly good example of these beds, and is unusually rich in organic remains, and also in flint implements.

The section exhibits :—

	Feet.
1. Brick-earth (loess) without organic remains	10 to 15
2. A variable bed of whitish, marly sand, with numerous *fresh water* and *land shells* of recent species, and a few *mammalian remains*...	3 to 7
3. Variable beds of subangular flint gravel—some white, others ochreous and ferruginous. Numerous *fossil bones* and *flint implements*, and a few *shells* as above, irregularly dispersed throughout..	5 to 14

These beds repose upon a base of chalk. The site having been long occupied as a Gallo-Roman cemetery, the upper brick-earth is intersected with pits and graves—in some there are stone, or rather hard chalk, coffins, whilst in others the nails and iron-work alone remain, the wood having entirely decayed away. These portions of disturbed ground are easily recognised by their darker colour, their contents, but more especially by the break they produce in the stratification of the beds. So long as the ground is undisturbed the lines of the brick-earth, the lamination of the sands, and the rough bedding of the gravel are continued in horizontal planes without break. Any interference from above breaks these lines and mixes the different beds, and renders the disturbance at once apparent. In the absence of any such indications it is to be assumed the fossils and the flint implements are in undisturbed ground.

The flint implements are found scattered irregularly through the gravel, but they are more numerous in the lower part. It has been estimated that there is one implement to one cubic yard of gravel. They occur singly, and as far as we know, lying flat. The spot where one was found *in situ* by Mr. Flower was pointed out in the section, and also the spot where the speaker and Mr. Evans extracted one. These worked flints partake of all the mineral characters of the gravel—the result of contemporaneous deposition. Some retain their original dark colour, others are stained yellow and brown—some have their outer surface converted to a bright white—many are incrusted with thin patches of carbonate of lime—and many again exhibit dendritic markings—all being conditions in perfect harmony with the mass of broken subangular flints composing the body of the gravel, of which they are, in fact, component parts, showing one and the other like characters of age. Several hundred specimens of flint implements from this pit have passed under the speaker's inspection; thirty selected specimens were exhibited, showing the principal forms which prevailed, and in which the workmanship and design were most apparent. Few can feel any doubt who inspect a series of this nature. It is not so much evidence of art and skill that we look for, but primarily of design. The speaker did not dwell on this point, which is now generally accepted. It has been well treated by Mr. Evans and others.

The fossils consist of perfect and uninjured, though very friable, land and fresh-water shells in the following proportion, and of bones, mostly broken, and teeth of the following animals. The list is necessarily only a sketch.

Fauna of the Quaternary Gravels of the Somme Valley.

	Animals.	*Shells.*
Extinct species.	Elephas primigenus.	14 species of land shells.
	——— antiquus.	
	Rhinoceros tichorbinus.	9 species of marine shells (Abbeville only).
	Hippopotamus.	
	Ursus spelæus.	
	Hyæna spelæa.	21 species of fresh water shells.
	Felis.	
some extinct, some living.	Cervus (2 or more species).	All these are of species living in France, and all but one in England, except the Cyrena fluminalis, now living in the Nile and Central Asia.
	Bos (2 or more species).	
	Equus (2 species).	

Proceeding to interrogate the section with a view to determine the causes which led to the formation of these beds, the nature of the climate which then prevailed and their age, the following conclusions were deduced :—

1. The mineral ingredients of the gravel are chiefly broken flints derived from the chalk of the district in general, but with these there occur fragments and blocks of tertiary sandstone and tertiary fossils, which could only have come from places 10 to 20 miles higher up the valley. Therefore the agency, whatever it was, that brought the débris here must have proceeded in a direction down the present valley, the tertiary débris being found along that line as far as the sea. Further, the cause could not have been a general one extending beyond the present hydrographical basin, for none of the older rock débris from the valley of the Oise, which is only separated by a water-shed six miles broad from that of the Somme, passes from it into the latter valley.

2. The presence of fresh water shells in some of the intercalated beds, many such as live in clear and rapid streams, indicate a probable fluviatile origin for these deposits.

3. The mammalian remains and land shells give evidence of dry land. The occasional occurrence of bones in the position they hold during life show that the carcases and limbs of animals were dropped into the old shingle before they were freed from their integuments, or within a short time after death—whilst the perfect state of preservation of the land shells is an indication of their not having been transported far.

All these characters tend to prove that these beds are to be referred to old

river action. This, however, must have taken place when the river occupied a level about 100ft. higher than it does now. It is true that similar gravels, containing similar mammalian remains and also flint implements, occur at lower levels (40ft.) in the valley, whence it is inferred that similar causes were in operation when these also were deposited. But it is plain that the two could not have been deposited at the same time. For the deposition of the high-level gravels on the supposition that the valley had been previously excavated, would have required a river at some times filling a channel more than a mile wide, and 100ft. deep—a state of things not to be accounted for under any circumstances. The alternative therefore of a river flowing at the higher level and gradually excavating its channel is adopted.

The character of the climate may be inferred from the fauna. The land and fresh water shells are of species now living in France, but they also range as far north as Russia, Finland, and Siberia. They are therefore such as, though occurring in temperate climates, are capable of existing in high northern latitudes. The animal remains furnish more positive testimony. The woolly mammoth and rhinoceros were fitted by their coating to endure the rigours of a cold climate, such as Russia and Siberia, where there remains abound, and where they seem to have fed on the vegetation common to such latitudes. A species of tiger now lives in central Asia, and is often tracked and hunted down in the winter on the snow and frozen lakes of that region. The reindeer, of which we have the remains in the valley of the Somme, and the musk ox, which occurs in the same deposits in the valley of the Thames, indicate still more clearly the northern tendencies of this group. There is a difficulty about the hippopotamus, but the elephant and rhinoceros originally presented the same difficulty; and there seems no reason why in this case also the extinct species should not be found to have been fitted to live in a severe climate.

These conclusions are corroborated by the physical phenomena. Mr. Prestwich pointed on the large section to numerous blocks of sandstone but little worn, and varying in weight from ½ to 5 tons, which could hardly have been carried and deposited, as now found, by water alone. He also showed various contortions in the upper beds of gravel (whilst the lower ones were hardly disturbed), and in the laminated sands overlying them. These he attributed to ice-action. The blocks, to transport from places higher up the valley on ice-floes at the breaking up of the ice in the spring, and the contortions to the grounding of ice-floes on the soft sand and loose gravel, impinging into them and piling up the gravel, as now occurs on the banks of some of the Canadian rivers. He pointed especially to the pendant masses of brick-earth isolated in the upper part of the sands, and which he attributed to angular masses of ice brought down in flood time, grounding on the brick-earth and pushing a portion of it into the underlying beds of sand, where, as the ice gradually melted, it would be left, caught, and squeezed in by the sand pressing itself into place again.

The two classes of evidence are, therefore, conformable. It is in harmony also with the existence of the large beds of brick-earth or loess overlying the gravel, and which is doubtlessly the deposit of the old river during floods, usual in a severe climate at the time of the melting of the winter snows. The winter climate may probably have been as rigorous as that of Northern Russia or Northern Canada. Such a climate would not be any bar to the presence of man, whose works are found in these old shingle beds. It is true that none of his remains have yet been found in these deposits, but they are found in caves of the same age. The abundance of animal remains is the almost inevitable consequence of a country subject to great river floods, by which large numbers of animals are always destroyed and swept down; man, on the contrary, guards against such risks. Along the Northern American rivers of the present day, although the remains of the buffalo and other animals occur in profusion, the remains of man are scarcely ever met with. There is every reason to expect that this further and desirable proof may be forthcoming at no long distance of time.

Lastly, the speaker stated that the present river Somme only carries down fine silt and mud, whereas the old river transported large masses of coarse shingle; therefore, it is to be inferred that the old river was one of much greater power than the present one. During floods especially, its power must have been very great; with greater transporting power the river would possess greater excavating power; at the same time the disintegration of rocks, especially such soft rocks as the chalk of this district, produced by severe cold, combined with the effects of ground ice lifting up from the bed of the river large quantities of the shingle, would hasten the deepening of the valley. As it deepened, terraces of shingle have been left at places on the slopes. It may be difficult to imagine a river with so limited a collecting ground filling a valley a mile wide, but this the speaker supposes to have been the case only during floods, and that the ordinary channel of the river was very much smaller. He instanced a case in India where Dr. Hooker mentions a river which was only 80 yards wide when he crossed it, but which after the rains covered a channel 3 miles wide, and ran 10 to 12ft. deep. The melting of the snow in the spring produces the same result in arctic regions as heavy and continued rains in southern regions.

Mr. Prestwich next exhibited a diagram to show what he conceived to be the different phases of the phenomena, from the period when the beds of St. Acheul were formed, until the valley assumed its present form and dimensions. The plan, which was formed of a series of superimposed sections, showed—

1. *The old river during the deposition of the shingle and sand banks of St. Acheul.*—In this the bed of the river was occupied with large shingle banks, which were left dry during the time the river was low. Mr. Prestwich supposes these to have been resorted to by early man, in consequence of the number of large flints they contained, for making flint implements on the spot. This may be one of the reasons why they are so numerous at St. Acheul, which was shown to be one of those old shingle banks preserved from that time. Ice-floes dropped large blocks of sandstone into the shingle. A space shut off in part by a shingle bank would account for the more tranquil accumulation of the middle sand beds of St. Acheul, and for the more numerous shells living there undisturbed. During floods the river rose probably to a height of 20 to 30ft. above its ordinary level, as shown by the brick-earth (without gravel) deposited higher up the hill on the road to Cagny. The next stage showed—

2. *The gravel beds of St. Acheul after they were left dry, except during floods.*—Here the valley had been excavated to several feet below the level of the St. Acheul beds, but during floods the river still extended over them and deposited the brick-earth. Ice-floes grounded and indented the upper beds of sand and gravel, causing contortion of the strata.

3. *The river at the time of the formation of the low-level gravel beds of St. Roch and Amiens.*—The valley had now deepened to the extent of 50 to 60ft. below the level of St. Acheul, and the low-level gravels of St. Roch were deposited under similar conditions, only that ice-action is not so strongly marked. It is in these beds that the remains of the *hippopotamus* first appear. The flint implements found in them are of a somewhat different type to those of the higher level gravels. The flake form is more prevalent.

4. *The low-level gravel of St. Roch, left dry except during floods.*—Here we have a repetition of the same state of things as found at St. Acheul; the shingle being covered up during floods by brick-earth or loess.

5. *The valley at the present period.*—The progress of excavation shows the valley deepened to its full extent. The river has lost its old power, its flood waters now rising only 2 to 3ft., and its channel being restricted within a very narrow compass. The old and rough channel left at the end of the quaternary period is covered to the depth of 10 to 20ft. by fine alluvial soil and peat. All the great pachyderms have become extinct, but the reindeer, bison, and great fossil ox survived during part of the more modern time. Almost all the small and fragile land and fresh water shells have continued in uninterrupted descent to the present day. This fact seems almost conclusive against any general cataclysm having passed over the surface. This concordance between the physical features and the contemporary life, and the capability the hypothesis here offered gives of explaining each and every one of the phenomena, affords strong presumptive proof of its truth.

Before concluding, Mr. Prestwich observed that he might be expected to say a few words respecting the age of the flint implements. Two questions were involved in this. One the length of time elapsed since the close of the period of the extinct mammalia—the other, how far back into that period the flint implements can be traced. In the description of the sections, it had been previously pointed out, that the quaternary period could probably be brought down immediately to the time when our valleys began their modern accumulation of silt and peat. The period of time, therefore, first to be measured, is that which has been required for the formation of these latter deposits. On this point there is considerable difference of opinion amongst geologists. The occasion did not afford time to enter into the details of the question, and the speaker therefore contented himself with an expression of opinion offered with reserve. He considered that more time and better data were required to make a sure estimate; nevertheless, he was satisfied that the evidence, as it exists, does not warrant the extreme length of time so frequently supposed.—The recent alluvia covering the latest quaternary deposits of our valleys are rarely more than 40ft. thick,—in most cases not more than 20ft. The rate of accumulation, though it may often be slow, is very variable. A Roman road in the valley of the Lea was found covered by 2ft. only of alluvium. Another such road in Cambridgeshire was covered with 5ft. of alluvium. The entire depth of the alluvium was not, however, ascertained in either case. M. Rozet gives another instance of a Roman road, which he considers to have been kept in repair until about the eighth century, traversing the valley of the Dheune. Its paved and even surface is now covered by 12½in. of alluvial soil. A little lower down the valley, this alluvian, which is very uniform, has been ascertained to be about 13ft. thick. This he estimates would have required for its accumulation about 10,000 years. The alluvial soil reposes there immediately on the so-called diluvium. The rapidity with which the alluvial soil will accumulate under favourable conditions is often very much greater. In places, thick beds of alluvium and of peat have been formed since the Roman occupation. Looking at these facts, and at the genera fact, that, as a rule, in the valleys of the Somme and of the Thames for example, the Roman, British, or Gaulish remains are found at a depth from the surface bearing a considerable proportion to the entire thickness of the alluvium, the probability is, that the commencement of the alluvial deposits is not to be carried back indefinitely.

One reason for believing the accumulation of the silty alluvium of our valleys to have been more rapid at one time than now, is that these valleys, left rude and rugged at the end of the quaternary period, would be subject to more frequent floods until their inequalities were filled up and levelled. Mr. Prestwich concluded by observing that "for these and various other reasons I am confirmed in the opinion I expressed in 1859, that "the evidence, as it stood, seemed to me as much to necessitate the bringing forward of the extinct animals towards our own time, as the carrying back of man in geological time." In making that observation I had chiefly in view the distance of time at which the last of the great extinct mammalia disappeared. If there should have been, between the modern valley alluvia and the latest quaternary beds, some intervening period of time of which we are ignorant, that distance may be materially prolonged. If, on the contrary, they followed in immediate succession, and I think we have evidence that such was the case, for there seems reason to believe that some of the large pachyderms still existed at the commencement of the alluvial period, whilst we know that many of the ruminants lived on uninterruptedly from one period to the other, I do not, for my part, see any geological reasons why the great extinct mammalia should not have lived down to comparatively recent times, possibly not further back than 8,000 to 10,000 years.

"But this only brings us to the threshold of that dim and mysterious antiquity in which first appear those rudely-wrought flints,—those evident works of design—those palpable shadowings of man. Here our chronology fails us altogether. If we look at our broad and long valleys, and then at the comparatively

small streams now winding through them, and suppose these streams to have been the same in past times as they now are, we could hardly avoid the conclusion that the time required to produce such excavations with such means must be almost incalculable. But if the view here proposed be correct, it would follow that with rivers so large in proportion to those now occupying the same valleys, with floods of a force now unknown in the same districts, with a cold so severe as to shatter the rocks, and to hasten the removal of their débris we should have, I contend, agencies in operation so far exceeding in power any now acting in these countries, that it is impossible to apply the same rules to the two periods. The changes described must have progressed with a rapidity of which we, at the present day, can in these latitudes hardly form an adequate conception.

"But although I would shorten the quaternary period by the extent of the differences here alluded to, it still remains of great length and importance, stretching back into a far remote antiquity, and it is far into this period that we have traced these works of man. Although at present we are without a scale or measure to determine that antiquity, we need not abandon the hope, that, by continued and careful observation, we may eventually succeed in forming some comparative estimate of it. The first men who, after traversing the plains of Lombardy, approached the Alps, could scarcely have failed to realize their vast dimensions, although without the means to determine their exact height; so we, from the relative magnitude of the phenomena and the variation of life, can sufficiently well realize the remoteness of the time in question, although we do not yet possess the data whereby to measure its duration, and determine its exact distance from our own time."

INSTITUTION OF CIVIL ENGINEERS.

DESCRIPTION OF THE SANTIAGO AND VALPARAISO RAILWAY, CHILE, SOUTH AMERICA; WITH REMARKS UPON RESISTANCES FROM CURVES ON RAILWAYS, AND UPON COAL BURNING LOCOMOTIVES.

By Mr. W. Lloyd, M. Inst. C.E.

It was observed that the original proposition for uniting the capital of the republic of Chile with its chief port was made by Mr. Wheelwright, an American citizen, in the year 1850. Detailed surveys and plans, prepared by Mr. A. Campbell, an American engineer, were submitted to the Government in the following year, for the construction of a line, the estimated cost of which was stated at about seven millions of dollars. In July, 1852, an Act of Congress was obtained by a company of Chillian capitalists; and in the month of October of the same year the works were commenced. Differences, however, arose which led to the service of a staff of engineers being secured from England, under the direction of Mr. C. Maugham; but owing to his decease, in May, 1854, the Author arrived in Chile, and took over charge as Chief Engineer. He then found that although a large sum had been expended, but little real progress had been made. On his recommendation a portion of the original works were abandoned, and an entirely new route adopted. He also endeavoured to place the workmen upon a more independent footing, provided proper tools and implements, with the requisite instruction in their use, and established, as soon as possible, the contract system. It this way the works were advanced with considerable rapidity; so that in September, 1855, a length of 8 miles was opened; by December, 1856, a further distance of 20 miles: and in May, 1857, the passenger traffic was opened to Quillota, a total distance of 34 miles from Valparaiso, but on a part of the last section the works were of a provisional character, pending the completion of a tunnel through the San Pedro hill. Thus far the line was carried out by Chillian capitalists, assisted by the Government. But its extension to Santiago, a further distance of 80 miles, was entirely executed on account of the State, who purchased the private stock at par. The first sod of the extension was turned in September, 1859, a length of 7 miles was opened in February, 1861, an additional 16 miles in September, 1862, and the whole of the line was completed in September, 1863, by the Author as Engineer-in-chief to the Government of Chile. The work had thus occupied nearly eleven years; it was believed, however, that it might readily have been accomplished in one-half the time, but for the delays and impediments arising out of the control of the authorities.

Respecting the physical features of the Republic, it was remarked that the extreme width of the country seldom in any part exceeded 100 miles; yet in this distance there was a difference of level equal to about 20,000ft. In fact the country resembled a vast mountain slope—its foot bathed by the Pacific Ocean, and its perpetual snow-covered summit lost in the clouds. The country was also volcanic, and subject to rain-storms of unusual violence. Being thus constantly liable to terrestrial disturbances, and not overburdened with pecuniary resources, the mode of carrying out such enterprises, with security and economy, was a deeply interesting study. Evidently, the first cost of construction was more important than the future cost of working, as an unusually high rate of fares would still be an enormous economy to the public, and high velocities were not demanded.

The distance in a direct line from Valparaiso (pop. 70,000) to Santiago (pop. 200,000) did not exceed 70 miles. The coach road between the two places pursued a tolerably direct course; but the physical obstacles upon this route rendered it indispensable to seek for some less obstructed means of access to the central valley of Chile. The road crossed three principal ranges of mountains, 1,300ft., 1,950ft., and 2,595ft. respectively above the sea level; while the two intermediate planes had an elevation of 830ft. and 1,000ft. above the same level, and the great central plain, in which Santiago was situated, was 1,800ft. above the sea. Merchandise was conveyed in large two-wheeled carts, drawn by eight bullocks, and capable of holding 2 tons, and the time occupied in the transit varied from six days to forty-four days, and the cost from £1 13*s.* per ton in summer to £3 17*s.* per ton in winter, the average being about 2*s.* 6*d.* per 100lbs. The opening of of the line would reduce the cost of conveyance of goods to one-third, and the time to five or six hours; while passengers, instead of paying £2 each by coach; would make the journey in one-half the time at an expense of 10*s.*

The line, as executed, left Valparaiso at its north-east extremity, followed the coast for a distance of 3 miles, crossing its various indentations, or cutting through the projections of syenitic rock. This portion was level throughout, being about 12ft. above high-water mark, and in many places was defended by sea walls of massive granite blocks; but it consisted of a series of curves of small radius. Thence it diverged to the east, and passed up the valley of La Villa del Mar for 5 miles, with gradients never exceeding 1 in 100, and after crossing the ravine of Paso Hondo, it reached the course of the Quilpue river, along which it ran for 10 miles, the works comprising deep cuttings in rock, heavy embankments, and considerable wrought-iron viaducts, the gradients in many places being as steep as 1 in 50, so that at the eighteenth mile the summit of Lebu, which was 510ft. above the Pacific Ocean, was attained. The line then descended for $2\frac{1}{2}$ miles at the rate of 1 in 65, and for $1\frac{1}{2}$ mile at 1 in 90, reaching the Limache river, which was spanned by three bridges, at the twenty-fourth mile. For the next 3 miles the line ascended again at the rate of 1 in 90, to surmount the second summit of San Pedro, the level of which was 384ft. above the sea. At this point the line passed through a spur of the Andes, by a tunnel 1,600ft. in length, two-thirds of which was through granite and trap-rock, containing much water, and the remainder consisted of decomposed rock and clay, so that it was considered necessary to arch the tunnel throughout. The completion of the tunnel having been delayed from a variety of causes, it was deemed advisable to form over the crest of the hill a provisional line, by which the traffic to Quillota was carried for four years, without the slightest accident. This line was worked by one of the ordinary passenger locomotives employed as a stationary engine, and by its means 250 passengers, and 100 tons of goods, were daily conveyed up inclines of 1 in 13 and 1 in 15 on either side, surmounting a height of 150ft. from the starting point. During the suspension of the tunnel works, the timbering under the wet decomposed rock became decayed; and when attempts were subsequently made to excavate the material, it flowed into the tunnel as fast as it could be removed, until the surface of the ground, 120ft. above, began to sink. The area of this settlement was observed to be much larger than the orifice below. When the ground had sunk 10ft., a large lattice timber framework was prepared to occupy this area, and upon this brushwood was spread. The excavation below was then proceeded with, the frame rapidly disappeared, and the sides of the cavity fell in as the frame descended. A second frame, similarly covered, was then inserted, after which the miners found they were gaining upon the slip, and eventually succeeded in getting the timbers properly erected. It was then discovered that the first frame had descended to the tunnel, and had perfectly plugged up the aperture.

Beyond the San Pedro tunnel, the line descended to the river of the same name, and again ascended to Quillota (pop. 10,000). This town was 34 miles from Valparaiso, and was situated on the Aconcagua river,—one of the principal in Chile, but not navigable in any part,—up the valley of which the line was carried for 20 miles. It then diverged to the valley of Tabon, crossed the Vichiculeu river, and at the fifty-seventh mile reached the station of Llaillay, where the Tabon Incline commenced. The characteristics of this incline, contrasted with other similar works, might be gathered from the following table :—

Name of Incline.	Open'd.	Length of Incline.	Total Rise.	Average Rise.	Sharpest Curve. Radius.	Summit over Sea.
		Miles.	Feet.		Feet.	Feet.
Alleghany Mountains	1851	15	1,690	1 in 47	600	2,626
Semmering	1854	$13\frac{1}{4}$	1,325	1 in 47	625	2,887
Bhore Ghaut............	1862	$15\frac{3}{4}$	1,831	1 in 48	990	2,027
Tabon	1863	12	1,360	1 in $46\frac{1}{2}$	604	2,640

There was a maximum gradient of 1 in $44\frac{1}{2}$ for a distance of $3\frac{1}{2}$ miles, and upon it occurred sixteen curves of 604ft., one of 633ft., and one of 702ft. radius, for an aggregate length of $1\frac{1}{2}$ mile. The railway had been carried along the abrupt and rugged sides of the mountains, at an elevation of 300ft. above the valley, the rocks towering above to an altitude of nearly 1,000ft. The works comprised two tunnels through porphyry, several heavy retaining walls, a number of high embankments, and a succession of deep rock excavations. At one point the line for one-half its width was in cutting 70ft. deep, while the remaining half was formed of embankment, the slope of which extended down the hill-side to about 250ft. below the rails. In the execution of this part of the line about three thousand men were employed for two years, the greater part being miners, and a large quantity of gunpowder was used. The Maquis Viaduct, the principal work of the kind upon the line, occurred on this incline, where the gradient was 1 in 46, and upon a curve of 604ft. radius. Its greatest height was 126ft. and length 600ft. The piers consisted of cast-iron columns, braced with wrought-iron, resting upon masonry. The superstructure comprised four plate-iron girders, each spanning openings of 100ft., and one tubular girder having a span of 148ft. The total weight of iron was about 750 tons, and the cost of the viaduct erected had amounted to about £40,000, or £66 per lineal foot. The iron work was all obtained from England; Messrs. Kennard supplying the piers, and the Canada Works the tube and girders. Out of the total length of 12 miles of the Tabon incline, $6\frac{1}{10}$ miles were curved; and upon all the curves of less than 1,000ft. radius, it had been deemed prudent to lay down a guard rail on the inner side. The permanent way was formed of fish-jointed T rails, 84lbs. to the yard, fastened to sleepers of two kinds of native timber.

The descent towards Santiago was effected, for the first 3½ miles, with an incliuation of 1 in 80, to which succeeded a gradient of 1 in 183, as far as the deep and tortuous ravine called San Ramon, along which the line was carried for four miles, with gradients of 1 in 55, 1 in 60, 1 in 71, 1 in 75, and 1 in 100. At the eighty-second mile the country became more open. The line then passed Tiltil, Poolpaico, Lampa, and crossed the Batuco Lake at the ninety-sixth mile, by means of an embankment, the slopes being protected by loose stone. Thence to Santiago, 114 miles distant from Valparaiso, the only works of importance were a cutting in basaltic rock at Renca, and a bridge over the Mapocho river, at the entrance to the capital.

American engineers appeared to underrate the effect which curvature produced in retarding the passage of trains; while English authorities differed materially in their views upon the subject. As the author believed practical data were wanting, he had appended to the paper a list containing the lengths of every curve and straight line upon the Tabon incline, specifying the gradient in each case. Further, he had made a few imperfect experiments, to ascertain the resistances due to sharp curves in combination with steep gradients, the results of which might be taken at all events as approximations to the truth. They were tried with a dynamometer, similar to a spring balance in its form and arrangement, but of only sufficient power to allow of one loaded waggon, of a gross weight of 10 tons, being employed. According to these experiments, the particulars of which were given in detail, upon a straight line with a gradient of 1 in 50, the resistances were 55lbs. per ton of train, corresponding with those deduced by the ordinary mode of calculation; while upon the same gradient combined with curves of 600ft. radius, the resistances were augmented to 70lbs. per ton of train. By the formula of Latrobe, the resistance due to this curvature was only 5·09lbs. per ton of train. Professor Rankine's gave 12·3lbs. per ton of load. These experiments appeared to show that, upon a curve of 1,000ft. radius, the resistance was double that upon a straight line; and upon a curve of 600ft. radius, it was equal to the gravity on an inclined plane of 1 in 50. Approximately, the resistance due to the curvature might be found, either by dividing the number of lbs. in a ton by 0·224 of the radius of the curve, or by multiplying the deflection angle of the curve by 1·75, to give the resistance in lbs. per ton of train. It should be stated, that the gauge of the line was 5ft. 6in., and that the proper super-elevation had been given to the outer rail on curves.

The plant employed upon the line was upon the European system, the engines and most of the rolling stock having been obtained from England. The engines at present in use, the dimensions of which were given, were of two classes, ordinary six-wheeled passenger and goods engine, four wheels being coupled; but special engines had been ordered for the Tabon incline.

Mr. Mather, the locomotive superintendent, had adapted the engines, at a trifling expense, to burn exclusively native coal, by which an economy in the cost and consumption of fuel, of about 30 per cent. had been effected. Observations as to the duty of the engines, on curves of 600ft. radius, showed that a velocity of 10 miles an hour, upon inclines of 1 in 44, ordinary passenger engines could convey a gross weight of train equal to double their own weight; upon inclines of 1 in 55, similar engines would take up rather more than two and a half times their own weight; and upon a gradient of 1 in 50, a goods engine had drawn up four times its own weight. The application of a jet of hot water upon the flanges of the leading wheels of the engines had so facilitated their passage round sharp curves, that bogie trucks were unnecessary, provided sufficient play was allowed to the trailing wheels; while the resistance was diminished, and the tires were not so rapidly destroyed. Similarly, the application of moisture to the rails from the tender, in passing round abrupt curves upon steep gradients, the rails for the engine remaining dry, sensibly reduced the resistance due to curvature; and by the same means the break blocks in descending inclines could be prevented from igniting.

The communication was accompanied by a series of photographic views, showing some of the more important works, and by complete plans and sections of the entire line, the cost of which had amounted to about £20,000 per mile, inclusive of rolling stock.

ON THE STRUCTURE OF LOCOMOTIVE ENGINES FOR ASCENDING STEEP INCLINES, ESPECIALLY WHEN IN CONJUNCTION WITH SHARP CURVES ON RAILWAYS.

By Mr. J. Cross.

After alluding to the torsion on the axles of ordinary locomotives when traversing curves, to the rapid destruction of tires and rails, and to the diminution of haulage power owing to the wheels becoming rail-bound, the author proceeded to describe in detail an engine fitted with Adams' radial axle-boxes and spring tires, which had been built for use on the St. Helens' line. This engine was on eight wheels, with a rigid wheel base of 8ft. only, being the distance between the centres of the coupled wheels, while the actual wheel base was 22ft. The radial axle boxes were only a little larger than ordinary engine axle-boxes; but instead of being square to the framing, they were struck with a radius having its centre in the centre of the adjoining axle, giving in this case a radius of 7ft., which the axle-box guide blocks were curved to fit. The boxes were allowed to play laterally 4½in. on each side; and the spring pin, instead of being fixed on the top of the box, was fitted with a small slide or roller, so as to allow the box to traverse freely from side to side, under it. Each axle-box weighed 3½ cwt., and the only additional parts were the spring pin rollers. While the engine was moving at high speeds, the boxes had an incessant lateral vibration. By the use of spring tires, an additional lateral motion was also possible, and such tires gave a better grip on the rail, as by slightly flattening under the weight of the engine, they presented more surface for friction. This engine was constructed to traverse curves of 200ft. radius, but had gone round one of 132ft. radius, and was then free from all jerking motion; was perfectly steady at 60 miles an hour on straight lines without a train attached; had taken seven carriages with a load weighing 72 tons up a gradient of 1 in 36, combined with a curve of 440ft. radius; and had been on regular duty on the St. Helens' line since November, 1863.

ON THE IMPEDIMENTAL FRICTION BETWEEN WHEEL TIRES AND RAILS, WITH PLANS FOR IMPROVEMENT.

By Mr. W. B. Adams.

The author thought that the chief source of destruction in rolling stock and permanent way, apart from disproportionate weight, arose from the blows and friction between the wheel tires and the rails—that was, jumping and sliding. This conclusion was verified by the contrary results practically obtained on the main line of the North London Railway at Bow. He considered that the best mode of preventing the blow was to provide for elastic resilience immediately over the tire beneath the wheel, and immediately under the rail, taking care that the rail joints were elastically supported by fishes of sufficient depth; a continuous elasticity which could only be obtained by discontinuous supports, as with the double-headed rail on an elastic base—the flat footed and bridge rails with continuous supports not being adapted for it; and that the rail thus elastically supported should be in itself as rigid as possible. On the North London line, this desirable result had been obtained, by laying down longitudinal timbers on the ordinary cross sleepers, and spacing the rail supports not on the cross sleepers but between them; the cross sleepers being packed, and the longitudinals unpacked; so as to yield elastic action. In a lapse of nearly two years and a half the ordinary iron rails laid on this system were undamaged, and the cross sleepers firm and unmoved, in marked contrast to the rails laid in the ordinary rigid way. He argued that the sliding, or frictional movement of the tires on the rails, could only be completely guarded against by permitting each wheel to revolve separately, or by permitting the tires to slip on the wheels; and at the same time providing for end play of the axles between the rails, in such a mode that the rails might govern the flanges, and keep the several axles at right angles to the rails, whether on straight lines or on curves. This had been accomplished by applying a hoop spring of tempered steel between the wheel and tire, enabling the tire to slip round on the wheel, or the wheel to slip within the tire, and the tire slightly to flatten in the case of driving wheels, and to rock laterally to fit an unequal surface of rail. These results had been practically verified on the North London and the St. Helens' lines, where Staffordshire tires under elastic use had far exceeded in durability Krupp's best steel. In conclusion, he remarked, that the sleepers, or foundations of the permanent way, could not be too firmly or too rigidly bedded; and that iron or stone blocks, as in the original system, chemically durable, might be advantageously substituted for timber, if elastic resilience were provided. The results of the cross sleepers firmly packed under the elastic superstructure, where the wheel pressure was distributed over two sleepers, instead of resting on one, demonstrated the advantage of a perfectly solid foundation.

INSTITUTION OF NAVAL ARCHITECTS.

Amongst the papers read at the ordinary meetings of this Institution on the 17th, 18th, and 19th of March, were the following. Want of space prevents us noticing the other papers until our next issue, when we purpose giving at length Capt. Symonds' and some other papers of interest:—

ON THE PRESENT STATE OF THE QUESTION AT ISSUE BETWEEN MODERN GUNS AND IRON-COATED SHIPS.

By Mr. J. Scott Russell, F.R.S., Memb. Inst. N.A., and Vice-President.

The present paper is a continuation of a series of Annual Notices which the author has given at these meetings of the progress which has been made in iron coated ships, and in the guns which are intended to destroy them. He commences by giving a table of the various thickness of armour-plating which the experience of the past year has showed to be worthy of the name of shot-proof against the new and improved weapons of the past year: 4½in. armour was proof against 68-lb. shot when the shot was cast iron, but now that round shot of steel have been introduced 5½in. are necessary. In like manner 6in. armour is required to resist the 9in. steel shot, while the 300-pounder with 70lbs. is a match for the 9in. plate. The author next proceeds to examine the naval guns of the French and of the Americans, and to consider what thickness may be reckoned proof against them. The next question examined is the capability of ships to carry guns of these large calibres and armour of the thickness necessary to resist them. He reviews the method of mounting large guns on turn-tables in revolving turrets, as introduced by Captain Coles in England, and Mr. Ericsson in America, and expresses an opinion that where the number of guns is not large the turret system is excellent and efficient, even for the heaviest guns now existing, and for the armour ready to oppose them. He gives a table containing particulars of the vessels which have been built on the turret principle in England and America. Proceeding to examine the capabilities of the broadside system, he expresses his continued confidence in the ability of armour-coated ships on the broadside system, both to carry the weight of increased size of gun and of the increased thickness of armour. He enters on a calculation which shows the ability of the *Warrior* class to carry her entire broadside of 300 pounders, and to carry the necessary increased thickness of armour over the whole length of her existing battery. The author next reviews the present state of the French iron-clad navy, which he examined at Cherbourg last summer. He expresses his approbation of the two-decker ship of the line class, which carries a double tier of breechloading rifled naval guns. The French guns fire seventeen shots for our ten, and carry double the number of guns of the *Warrior* in their central battery, besides being faster and easier in a seaway than the single-decked vessel of their own class. The author concludes by pointing out the conditions on which

English ships of the *Warrior* class may now be built, so as to carry in their central battery an entire broadside of 300-pounders, and how a two-decked ship of the line may be constructed to carry a double tier of such guns with the corresponding thickness of armour.

ON THE PRINCIPLES OF CONSTRUCTION AND THE ARMAMENT OF IRON CLADS.

By Captain R. A. E. SCOTT, R.N., Assot. Inst. N.A.

Captain Scott points out the disadvantages of ships built entirely of iron or of wood, and calls attention to the economic importance of still continuing some use of wood in the construction of the Royal Navy, both on account of the immense stores contained in our dockyards, and the large staff of skilled workmen, who are excellent ship carpenters, but who could hardly be trained to make good smiths. He next remarks upon the necessity of breaking the force of an attack by interposing some obstacle in front of the main defence, using the analogy of a strong fort masked by comparatively slight out-works. Hence Captain Scott proposes to use an iron framing, with the usual iron plating, and a thick wooden outside covering, instead of the wooden backing at present in use, for the construction of fighting ships. The bottom of the ship, he proposes to construct entirely of wood (except framing) filling up the spaces between the iron frames completely with wood. The bottom of the vessel can thus be coppered, so as to avoid the excessive fouling to which iron ships are subject. With regard to the armament, Captain Scott goes into detailed arguments showing the advantage which a heavy concentrated armament possesses over a large number of guns of small calibre. Hence, for his armament, he proposes to mount a small number of muzzle loading guns of the very heaviest calibre on the central portions of the ship. The paper closes with a full description, and specification of a particular ship designed upon these principles.

ON THE STEERING OF SHIPS.

BY MR. HENRY LUMLEY, Assoc. Inst. N.A.

Mr. Lumley prefaced the description of his improvement in ships' rudders, known as "Lumley's Patent Rudder," by observing that the invention did not depart from the principle of the ordinary rudder, but availing itself of the valuable features possessed by that instrument of simplicity, rapidity of action, and the power of being worked from deck by hand, the new invention intensified and increased its effects because the relation of the surface of the new rudder to the fluid in which it worked was of a character to produce better results. Taking in a great measure the tail of a fish for a guide, and adopting therefrom the curved instead of the plane surface, this rudder has been devised, combining strength, simplicity, and self-action with the recessed or curved instead of the usual plane or straight surface to resist the current produced by the passage of the ship through the water. Mr. Lumley then, with the help of several handsome models, pointed out the alteration of the common rudder to one of the new plan, and explained that it consisted of a vertical division of the ordinary rudder, the junction of the two parts by pintles and braces and by one of three distinct methods bringing about the recessing or curving movement. The first of these methods is to affix two chains to the stern-post on opposite sides, crossing each other in the "body" of the rudder and then fixed to the outer edges of the "tail." The second, to carry a short tiller from the tail to an axis under the counter of the ship. The third, a yoke-piece from the tail with an arm carried to a point near the stern-post. Mr. Lumley then described the results of the new rudder in the ships of war and merchant vessels fitted—in round numbers the difference between the ordinary rudder and Lumley rudder being as much as 50 per cent. in favour of the latter—showed that by these results the success of the invention was established. The three points of strength, simplicity, and efficiency were then mentioned, and after stating that the new rudder at an angle of 10 degrees of tiller is equal to the old rudder at an agle of 20 degrees, and the consequent advantage therefrom, Mr. Lumley explained the universal utility of such a rudder, its value in river and intricate navigation, the prevention of collisions, its applicability to sailing ships and screw and paddle steamers, the increasing of length of such vessels by the use of this rudder, and other important features. Mr. Lumley concluded by acknowledging the encouragement he had received in the establishment of his invention from the shipbuilding interest, and more particularly from the English Admiralty and the Controller of the Navy.

TRIBUTE TO THE LATE RICHARD ROBERTS.—An influential meeting was held on the 27th ult., at the house of the Society of Arts, to consider the most appropriate manner of testifying to a general sense of the important services rendered by the late Mr. Richard Roberts to manufacturing industry and mechanical science. The following resolution was proposed by William Fairbairn, Esq., LL.D., F.R.S., seconded by Thomas Basley, Esq. M.P., and carried unanimously: "That this meeting is of opinion that the eminent services which Mr. Richard Roberts has rendered to the manufacturing industry of this country, and to the world at large, by his useful inventions, demand some substantial and permanent record, and that the most appropriate tribute to his memory would be, in the first instance, to provide for the independence of his only daughter, and that for this purpose a fund be raised by public subscription." The following noblemen and gentlemen were appointed a committee to carry the above resolution into effect: His Grace the Duke of Sutherland, the Earl of Caithness, Lord Stanley, M.P., Lord Alfred Churchill, M.P., Admiral Sir Edward Belcher, Thomas Bazley, Esq., M.P., John Pender, Esq., M.P., Dr. Fairbairn, Colonel French, Mr. Zerah Colburn, Mr. Bennet Woodcroft, Mr. Webster, Mr. Trotman, Dr. Whitehead, James Wilson, Esq., A. Hutton, Esq., Mr. P. Le Neve Foster, Hon. Sec., and others.

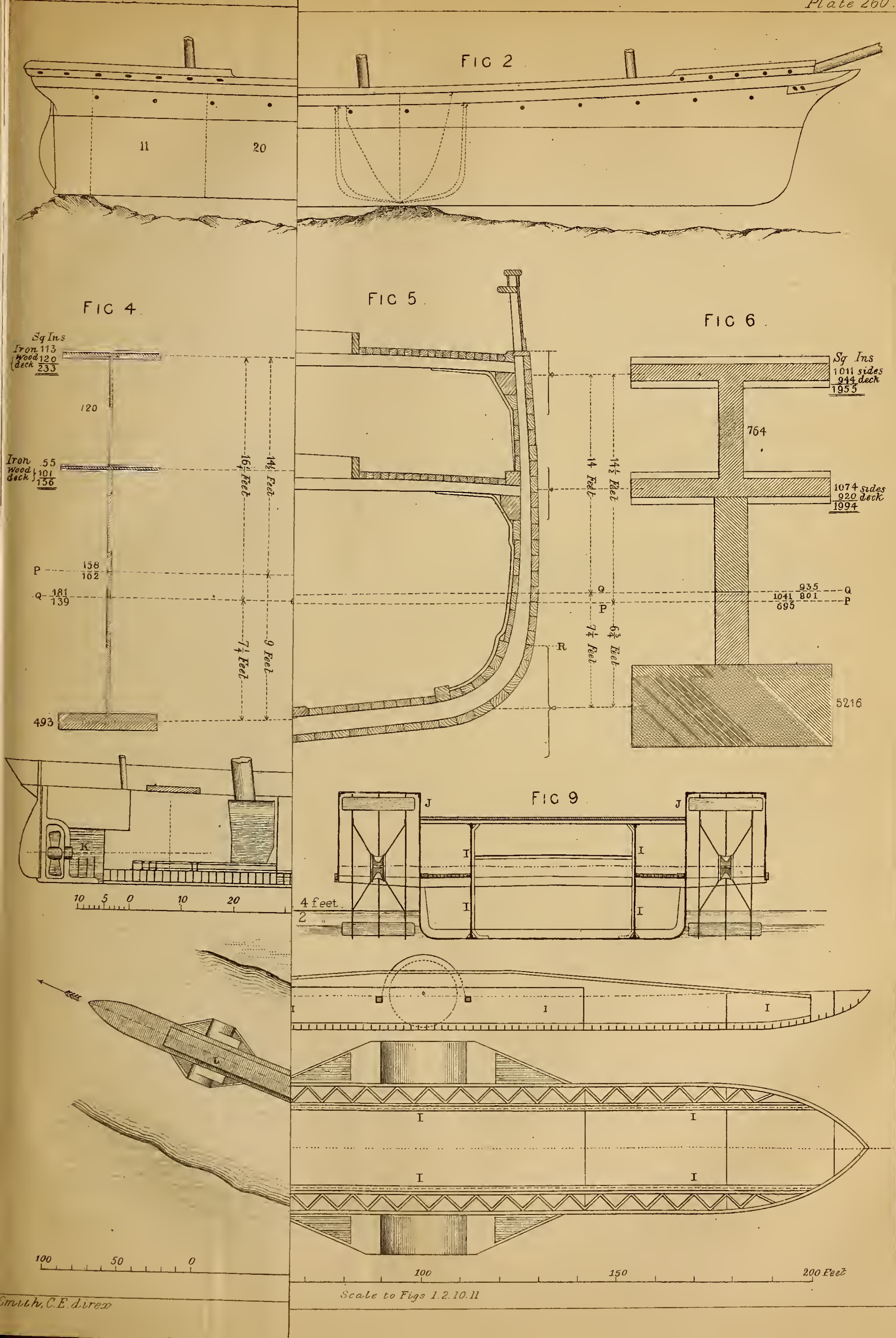
CURRENCY.

The currency of the world includes many kinds of money. Gold, silver, copper, iron, in coins or by weight—stamped leather, stamped paper, wooden tallies—shells of various kinds—pieces of silk or strips of cotton cloth, of a fixed size and quality—are, or have been all in use among mankind as forms of currency, as convenient or negociable forms or representatives of property. Many of these kinds of money are simultaneously in use in the same country. Gold, silver, copper, and stamped paper coexist as different forms of money in the currency of Europe and America; gold, silver, copper, and shells in India; silver, copper, and pieces of silk in China; copper, cotton-strips, shells, and the silver dollar in various parts of Africa. Sparta had a currency of iron. There is ample variety in the substances out of which money is made—metal, shells, cloth, leather, paper; and, moreover, every country shapes the substances, or such of them as it uses, in a different form from the others. The generic quality which constitutes money is manifestly something extrinsic to these substances—some quality superimposed upon or attributed to them, or at least to the shape they assume as currency. Gold coin is not money in China, it is silver.* In England silver is not a legal tender, save to the extent of forty shillings, in payment of debt. Above that amount it is simply bullion: it is no more money than brass or tin or platinum is. Half a dozen kinds of silver coin are current at Shanghai—five kinds of the dollar and the Indian rupee; but a few years ago only one of these coins, the old Spanish Carolus dollar, was a legal tender. This state of matters was remedied in the autumn of 1855.

The States of Europe have in some respects almost become a commonwealth, but the currency of one state will not circulate in another. The English sovereign, indeed, is readily taken in payment in some parts of the Continent; but even *it* does not circulate there—no more than Napoleons will circulate in England. Although the coins of one country will not circulate in another, gold and silver are recognised as the raw material of money all over Europe and America, and are valued accordingly; but paper money out of its own country may be said to carry no value at all. Bank of England notes, indeed, which have the same prestige over all other kinds of paper money which the sovereign has over other coins, may be used without difficulty in Paris, and at no greater charge than is made for converting sovereigns and half-crowns into French money. But even in the same country there is often a limitation to the circulation of some kinds of money. The sovereign, though a legal tender and readily accepted when offered in payment, hardly circulates in Scotland—the Scotch preferring paper money, as the most safe and convenient form of currency, and also as the cheapest. Scotch bank-notes, again, are not a legal tender in other parts of the kingdom. In England, too, there are many provincial banks, the notes of each of which circulate readily in the districts where the issuing banks are situated, but are looked upon with suspicion elsewhere; they will not circulate widely, simply because they are a kind of money with which the public at large are not familiar, and in which, accordingly, they have no confidence.

The English provincial banks are very much like the State banks in America. Of all forms of money silver is the most widely recognised, and, therefore, holds the first place in the currency of the world. It is the standard money of China, with a population of 400,000,000, and of India, with a population of 160,000,000. It is also recognised as money all over Europe and America. Gold, at present, holds the second place in the currency of the world. But unless new silver mines are found, the recent discovery of the gold deposits in California and Australia will make gold more abundant and more cheap, and tend to wrest all supremacy from silver and give it to gold—by inducing the European and American States to make all the necessary additions to the metallic portion of their currency in the latter metal. Next in amount of circulation to gold and silver money, comes paper, issued under legal restrictions. In England, France, Austria, and Russia, the amount of paper money in circulation is very large, but not so large in proportion, at present, as in the United States. Paper money has the widest range in value of all kinds of money. It is also the cheapest and most portable. In the form of bills of exchange—which, however, are not a legal tender—paper money plays the most important part of all, in carrying on the commerce of the world. It may also be used as a substitute for all kinds of money—if under proper restrictions, with perfect safety and great economy. And in modern times it has always been had recourse to, with more or less prudence and advantage, by nations who in exceptional times find themselves in a temporary deficiency of metallic money. It should never be forgotten that money is a mere medium for the exchange of useful and necessary products.—*Scientific American.*

* See also the article on the New Currency and Mint at Hong Kong, in THE ARTIZAN of February last.



time
arged

ressel,
uring
same

smatic
would

out as
on we

untry,
; two-
com-
order

ither's
it the
pipes
into a
pipes,
is so
e have
rmulæ
experi-
made
ft. per

es ex-
s into
ll be,

b. ft.

580 as
calcu-
sbach).

at the
et per

aking
head
have

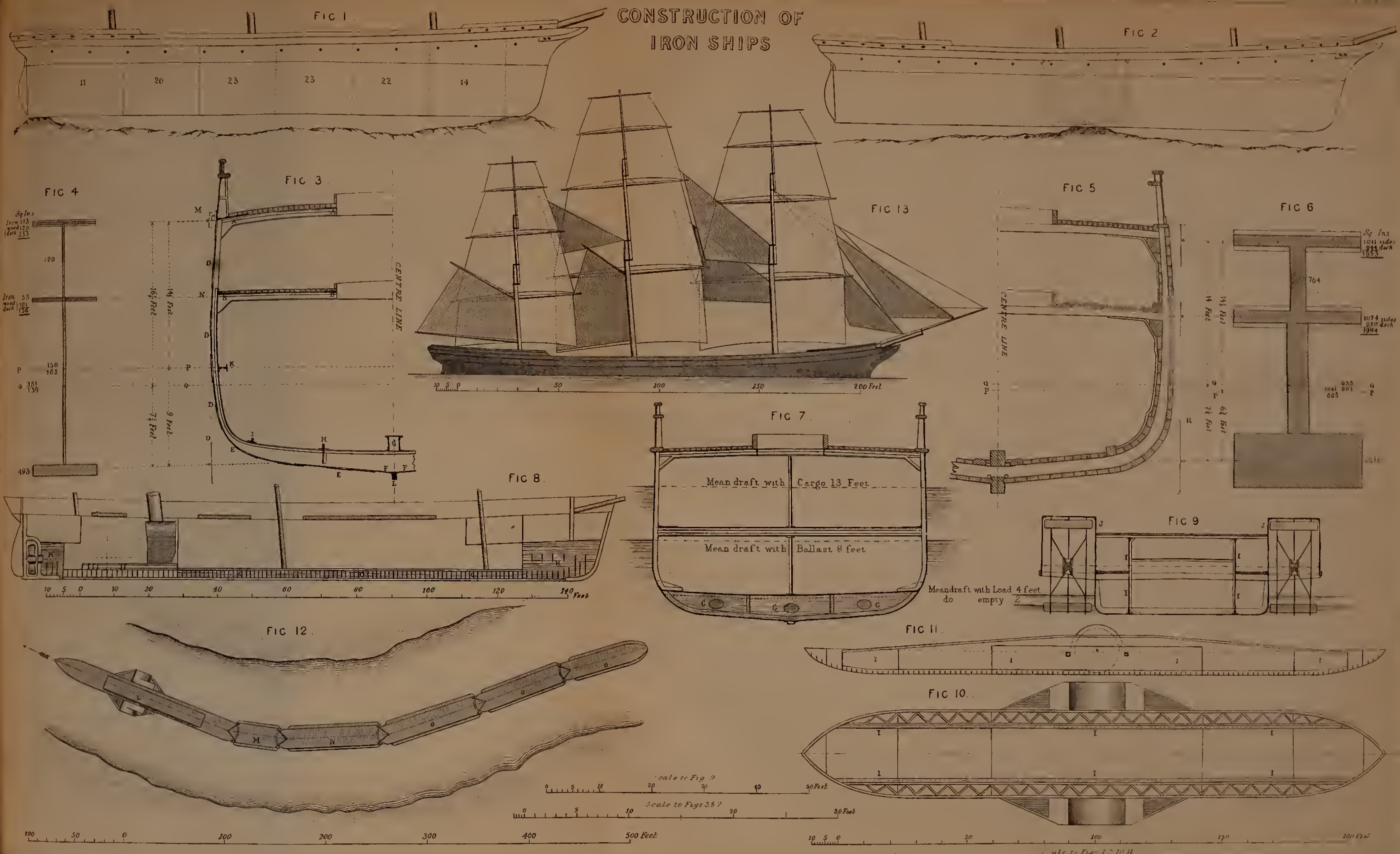
, and

EL.

I see
in ex-
y im-
gines
s are
out of
year
air as
erage
d the
wing

ating
ng an
e one
rated
g up
mple
of air

CONSTRUCTION OF IRON SHIPS



Engli
centr
of th
respo

ON T

Cap
wood,
use of
mense
who a
smith
by int
a stro
propos
outsid
structi
entirel
compl
avoid
arman
which
small
of mu
ship.
ship d

Mr.
as "Li
from t
feature
power
increas
fluid in
a great
instead
simpli
or str
throug
models
and ex
junctio
metho
metho
other i
"tail."
counte
to a p
new r
the dif
50 per
the in
efficien
angle
and th
utility
of coll
the in
portan
he had
intere
of the

Tr
held o
appro
rende
chani
Esq.,
mous
Richa
to the
perma
be, in
and th
ing n
resolu
Lord
Thom
Frenc
Dr. W
Hon.

CORRESPONDENCE.

We cannot hold ourselves responsible for the opinions of our Correspondents.

THE BRADFIELD RESERVOIR.

To the Editor of THE ARTIZAN.

SIR,—With respect to the article on the Bradfield Reservoir, permit me to call your attention to the fact that the mean discharge of a pipe by which any vessel of water is emptied, is not one-half of the discharge due to the maximum depth, but two-thirds of that discharge. It is a fact proportional to the mean of all the square roots in the depth, or, in other words. to two-thirds of the square root of the maximum depth. Mr. Leather was not, therefore, very wrong in his calculation.

I may add that the sudden failure of the Bradfield Reservoir was not consequent upon error of design or faultiness of construction, and I venture to refer you to the evidence given at the inquest for the purpose of convincing you that none of the witnesses examined before a more than willing coroner would pledge himself to the expression of a well-considered opinion to that effect.

I am sorry to see Mr. Leather unduly blamed; and I am sure you would not willingly lend yourself to the infliction of additional pain on an undeservedly suffering man. T. HAWKSLEY.

To the Editor of THE ARTIZAN.

SIR,—In answer to Mr. Hawksley's letter we have to say that, while condemning the principle very generally, though not universally adopted, of placing the puddle wall in the centre of an embankment of this kind, we distinctly stated that we had no desire to criminate Mr. Leather, who, we think, was perfectly justified in imitating those who have preceded him. But we cannot withdraw one single sentence from the remarks we have made on the subject of the quality of the work and on the manner of carrying the same forward in layers of more than 6ft. in thickness, in glaring contravention of Mr. Leather's specification; these remarks, moreover, are borne out by the evidence of Messrs. Rawlinson and Beardmore, given at the coroner's inquest, to which we are referred. Mr. Rawlinson's statement being that "he had no hesitation in coming to the conclusion that that embankment was as porous as a sieve," and, indeed, the matter is not one of "opinion," but, to those who have seen it and who are willing to trust the perceptions of their own senses, it is one of "fact."

Now it does happen that engineers have to make embankments with a material which is at all times as porous as a sieve, namely, sand; and we apprehend that if Mr. Hawksley were called upon to carry out such a work he would, without seeking for a precedent, place the puddle wall on the water side of the slope of the embankment, lest, if he placed it in the centre "as usual," one half of the embankment should be washed away by the mere infiltration of the water, when the other half would have to follow in consequence of inadequate strength. This, at any rate, is what the engineers to the Mersey Dock estate have done at the Leasowe embankment, and thus are the conclusions which we have drawn from "the fact" of porousness of the Bradfield embankment in reference to its failure indirectly justified, if not verified by another fact, of which, at the time we wrote our report, we had not taken cognizance.

Nor can we withdraw our statement that the engineers of this work have laid themselves open to the charge of great carelessness by not draining the ground in the immediate vicinity of the outer slope of the embankment, and by allowing a copious stream to discharge itself right upon the foot of the dam, but we again dwell with great stress upon this fact, which seems to have escaped the notice of all those who were called upon to give evidence at the inquest, although there were no two opinions as to the mischievous results which would follow the "percolation" of water under the outer slope, and it is difficult to conceive "why" the effects through "infiltration" of water from outside should be different from those of percolation from inside.

With regard to our statement that the time required for a reservoir to empty itself under a constantly diminishing head, is double that required if the velocity of outflow was constant, having supported the same by an algebraic demonstration we did not expect to have that statement contradicted, for algebraic demonstrations of this kind partake of the nature of material facts which no theory or argument can overthrow, and when the starting point is correct, if the conclusion arrived at is erroneous, the error must be detected in the process which has led to that result. In order, therefore, to enable all our readers to follow us and to see that we had no desire to mislead, we have laid down our premises with great clearness, and given the entire process, the demonstration in its entirety challenging investigation; but we presume that, upon further consideration, it will occur to Mr. Hawksley that, above all things, the time required is inversely proportional to the "mean of all the speeds," which, since these vary from a known quantity to nothing in a uniformly diminishing ratio, must be equal to one half the maximum speed, and consequently the time required double of that if the speed had remained what it was at the beginning of the period of efflux.

Inasmuch, however, as the teachings of scientific men of undoubted authority command a degree of conviction which is not imparted by those of ordinary mortals; we here quote in full the demonstration given by D'Aubuisson in his work on hydraulics, probably the most complete ever published. He therein says, Chap. II, paragraph 87:—

"According to the laws of uniformly retarded motion, when a body starting with certain velocity gradually loses it till it is reduced to zero, it passes through half the space it would have passed through in the same time if it had constantly preserved the velocity of departure. Moreover the volume of water which flows from a vessel until it is quite empty, may be regarded as a prism having for its base the orifice in the vessel and for its height the space which the first effluent particles would pass through, with a retarded motion equal to that with which the efflux is made; but if these same particles had always preserved their initial velocity (that due to the first head), the space passed through in the same time or the height of the prism, and consequently the volume of water discharged would have been double."

Hence the theorem;—

"The volume of water discharged through an orifice from a prismatic vessel, which entirely empties itself, is only half of what it would have been during the time of emptying, if the efflux had taken place constantly under the same head as at the commencement."

Or, inversely: A given quantity of water discharging itself from a prismatic reservoir under a constantly diminishing head (until that head is zero), would have discharged itself in half the time, if the head had remained constant.

This reciprocal is demonstrated algebraically in D'Aubuisson's work, but as the result is identical with the one we have arrived at in our demonstration we do not reproduce his calculations.

If at all the belief is prevalent among hydraulic engineers in this country, that the mean discharge of a pipe through which a vessel empties itself is two-thirds of the discharge due to the maximum head, the hydraulic blunders committed must be very numerous, and it is time such belief be dispelled, in order to save further mistakes and further accidents.

Indeed if at all we have made any error, it is one in favour of Mr. Leather's statement, for in calculating the discharge, we have not taken into account the very considerable reduction occasioned by friction through a range of pipes 500ft. in length discharging their contents not into an open space, but into a culvert of an area only about treble that of the aggregate areas of the pipes, and of some three miles in length. But the head of water in this case is so much greater than was contemplated by any of the authorities which we have on this subject, that we trust, with diffidence only to any of the formulæ which they give to calculate the flow of water through pipes, since the experiments upon which these formulæ are based do not appear to have been made upon greater heads than such as will produce velocities of from 7ft. to 10ft. per second.

Thus if we take D'Aubuisson's formula for high velocities (*i.e.* velocities exceeding 2ft. per second) and assume that the pipes discharge themselves into an open space, the volume in cubic feet per second for the two pipes, will be,

$$Q = 2 \times 36{,}769 \sqrt{\frac{H\ D^5}{L}} = 2 \times 36{,}769 \sqrt{\frac{90 \times 1{,}5^5}{500}} = 86 \text{ cub. ft.}$$

or 5,160 cubic feet per minute under the greatest head, instead of 14,580 as was stated in the portion of our report already published; or else, if we calculate the discharge by Rankine's formula (probably translated from Weisbach). which is as follows:—

$$v = 8{,}025 \sqrt{\frac{H\ D}{4 f L}}$$

$$4 f = 0{\cdot}0144 + \frac{0{\cdot}0172}{\sqrt{v}}$$

we find for the velocity of discharge by two approximations,

$$v = 31{\cdot}2 \text{ft. per second.}$$

and the discharge per minute,

$$31{\cdot}2 \times 60 \times 3{\cdot}55 = 6645{\cdot}6 \text{ cub. ft.}$$

from which a deduction must be made for contraction of the vein at the inner opening of the pipe, leaving a discharge of, say 6,000 cubic feet per minute.

At this rate it would take twenty-six days to empty the reservoir, but making some allowance for the reduction in the area of the reservoir as the head lowers, it might be put at twenty-two days, or double the time which we have given, and nearly treble that given by Mr. Leather.

As stated before, however, we give these figures with some diffidence, and must leave the profession to form their own opinion about them.

J. J. BIRCKEL.

To the Editor of THE ARTIZAN.

SIR,—Although smoke from steam ships is such a recognised nuisance, I see few, if any, means taken to effectively prevent it; and, although fuel is an expensive article, I still find the apparatus for consuming it, generally in a very imperfect condition. Always in going below, a handsome well-kept pair of engines presents itself to your gaze, but look at the boilers, the furnace fronts are most likely cracked, the doors in bad repair, and the fire bars more or less out of order, and this when the furnace is an apparatus for consuming fuel every year to nearly half the value of the machinery, and should be kept up in repair as carefully as the slides of the engines themselves. I have lately seen the average calorific value of Welsh and Newcastle coal, raised nearly 14 per cent., and the power of the boiler producing steam raised to the same extent by the following simple alterations, viz.:—

Reducing the length of the bars so as to increase the proportion of heating surface to about 33 square feet per square foot of grate surface, and securing an efficient combustion chamber, and by adopting a furnace door similar to the one shown in the sketches, when it will be seen that the baffle plate alone is perforated with as many $\frac{7}{16}$th holes as practicable; the door, being intact, the air coming up through the bottom space only between the door and the baffle plate. Any simple shutter for this bottom space will give the means of regulating the quantity of air

going through, which, however, does not seem to be greatly wanted. In a furnace so constructed the most bituminous steam coal may be burned with the greatest

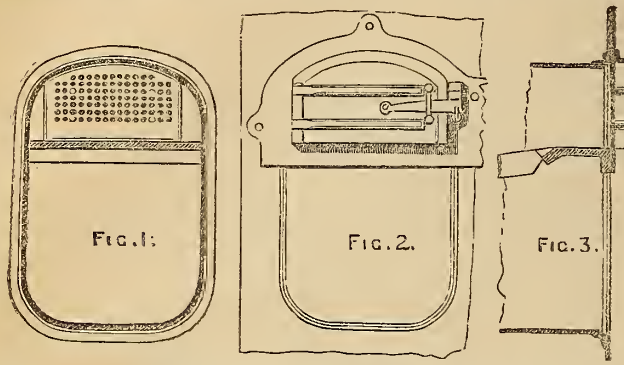


Fig. 1. Fig. 2. Fig. 3.

economy almost entirely without smoke, by the most careless stoker, and the boiler made to produce the greatest possible amount of steam in a given time.

If you think that these remarks will interest your readers, please insert them.

Thos. Wm. Bunning.

REVIEWS AND NOTICES OF NEW BOOKS.

Mémoire sur l'application de l'algèbre aux calculs des bâtiments de mer. Par J. A. Normand. Paris: Arthur Bertrand.

In this pamphlet the author, a naval architect of Havre, endeavours to lay down rules embodied in simple algebraical formulæ for finding the correlative proportions of the inclinations, the dimensions, areas of sections, weights and volumes of vessels when one or several of these factors are given. The author, in referring to Mr. Nystrom's paper on the parabolic construction of ships, which was published in The Artizan of May 1, 1863, states he is of opinion that the object of calculations in naval architecture consist solely in the determination of the proportions to be given to the *ensemble* of the constructions, and that the designing of the curves should be left to the discretion and taste of the shipbuilder without being limited by compulsory rules as to the proportions of abscissæ and ordinates. We hope that the formulæ given by M. Normand will be found to be available for practical purposes.

BOOKS RECEIVED.

We have also received the following works, too late for notice in the present number, but which shall be reviewed in our next:—

"The Design and Construction of Harbours." By Thos. Stevenson, F.R.S.E., &c. Reprinted and enlarged from the article "Harbours" in the eighth edition of the "Encyclopædia Britannica." Edinburgh: Adam and Chas. Black. 1864.

"An Elementary Treatise on Orthographic Projection and Isometrical Drawing," designed for schools, members of science-classes, &c. By W. S. Binns, M.C.P., author of "A Course of Geometrical Drawing." London: Longman, Green, Longman, Roberts, and Green. 1864.

"Annual Report of the Chief Engineer of the Water Department of the City of Philadelphia, presented to Councils, Jan. 28, 1864." Philadelphia: Andrew W. M'Clarky. 1864.

NOTICES TO CORRESPONDENTS.

A Subscriber (Plymouth).—The subject of your letter is one which can be more satisfactorily answered through the post. We will send you through that medium the full particulars which you seek to obtain.

A. A. R. (Sunderland).—The proposed parallel motion, as illustrated by the sketch you have enclosed, is, we consider, a very bad application.

T. R.—The *Buckeye State* was built in Cleveland, Ohio, in 1851 as a passenger boat for Lake Erie. The engine, with the exception of the cylinder, was the ordinary condensing, vertical, overhead beam, with lifting air-pump. The small high pressure cylinder was directly within the large low pressure one, which thus had necessarily an annular piston; both pistons were connected to the same crosshead by three piston rods—one from the central and two from the annular piston. In this arrangement the steam was required to pass through pipes equal in length to the cylinders themselves after leaving the small piston before it could act upon the large one.

RECENT LEGAL DECISIONS
AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

Under this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

Hill *v.* the Midland Railway Company.—The plaintiff, being very fond of flowers and fruit, took a lease for forty years of two acres of land close to the Apperley-bridge station of the Bradford and Leeds Railway, and built himself a house there at a cost of about £3,000. He constructed large green-houses, hot-houses, and orchard-houses, at a very considerable expense, and now sought to recover from the railway company damages for inconvenience in the occupation of his house, and injury to the garden occasioned by smoke issuing from the company's engines. The special Act empowering the company to make their railway required that the engines should be so constructed as to consume their own smoke; and, up to the year 1859, the company had always burnt coke in their engines, which caused no smoke. In that year, however, instead of coke the company began to use coal in their engines, and it was of the annoyance caused by the smoke from this coal that the plaintiff now complained. His case was that upon this change in the fuel the engines going by the Apperley-bridge station, through which eighty-six trains passed in the course of the day, vomited forth great clouds of black smoke, which settled upon his garden, and produced great injury to the shrubs and flowers. He complained to the company, who explained that the smoke was caused by the change from coke to coal, and stated that they were engaged in experiments with a view to ascertain what alteration in the construction of their engines would best fit them to consume their own smoke. The case on behalf of the company was that they had gone to great expense in constructing engines in such a way as to consume their own smoke, and at last Mr. Markham, their assistant locomotive engineer, had produced an engine which it was believed and admitted by the other side accomplished this object as far as could possibly be done. The air entering the fire place was deflected on to the surface of the coal, and the smoke arising from the combustion had to pass under a heated arch composed of fire brick, which, when the engine was in motion, completely consumed the smoke, owing to the draught caused by permitting the waste steam to escape up the smoke funnel. When the engine ceased working, the draught thus caused was of course diminished; but a similar effect was produced by introducing steam from a steam jet into the funnel. The engine-drivers and stokers received strict injunctions to turn on this steam jet whenever the engine ceased working on approaching a station, and their attention was stimulated by a premium they received in proportion to the saving of fuel they effected. Several witnesses were called, who stated that there was hardly any escape of smoke from the engines passing through the Apperley-bridge station. His Lordship directed the jury that by the common law the company were bound to take every reasonable precaution to prevent the smoke from doing any injury. The Legislature had required that they should use engines so constructed as to consume their own smoke; but, even if that were done, they would be liable if, by the negligence of their servants, the smoke was allowed to escape in such a manner as to become a nuisance to others. If the smoke escaped in such a way as to cause real and sensible injury to his garden—such inconvenience, that was to say, and such injury as a sensible man would reasonably complain of, and not merely a fanciful inconvenience or injury—the plaintiff would be entitled to their verdict. If they were not satisfied of that they ought to find against him. The jury immediately found a verdict for the defendants.

Bovill *v.* Hadley and Others.—This was an action by Mr. George Hinton Bovill, engineer, against Messrs. Hadley and Co., corn millers, for their use of a patented invention of his, for "improvements in manufacturing wheat and other grain into meal and flour." It appeared that for a long series of years Mr. George Bovill had directed his attention to the subject, and had taken out a patent for some similar improvement, and the essence of which seemed to be a contrivance for ventilating the grinding surfaces of millstones and the introduction of the air through the top stone when fixed either by blowing or exhaustion, together with a process for exhausting the air from the cases of millstones, combined with the application of a blast to the grinding surfaces. Mr. Bovill, Q.C., in opening the case on the part of the plaintiff, referred to and cited a report of the Admiralty, observing that it would not in itself be legal evidence, but that in effect it would be made so, for he should call as witnesses two of the gentlemen who had made it. He assumed as the basis of his case a *minimum* saving of 2*s.* 6*d.* a quarter by means of the invention, and the sum of 6*d.* per quarter (originally agreed to be paid by the Government) as the fair rate of remuneration. And he urged that one-fifth of the actual average saving, at the lowest estimate, was hardly an unfair rate of remuneration to the inventor. As generally happened with inventors the expenses incurred by the long delays and difficulties encountered before the value of the invention was appreciated, had prevented his realising a fair amount of remuneration before the expiration of his patent, and hence it was that the Privy Council had renewed it for five years. The leading millers, however, had combined to oppose it; but the defendants, who were large millers, were well aware of the value of the invention, and had used it for years. They had entered into negotiations for the plaintiff's licence for the use of the invention for the whole of the renewed term of five years, at the low rate of 2*d.* per quarter. But, although the plaintiff might have been willing to accept that low rate for the whole of the remaining term, it was manifestly quite different when the invention had been used for a short period without any agreement. During that period the defendants had ground 65,000 quarters of wheat, on which their saving, at the rate estimated by the Admiralty (of 2*s.* 6*d.* per quarter), would amount to £7,600; and of this large sum the plaintiff only claimed, at the Admiralty rate, one-fifth of the estimated saving. Mr. George Hinton Bovill being called as a witness, described the nature and results of his invention. The evil of the previous process was, he said, that the flour was "overground." The millstones went on working, grinding as well the flour already ground as the new grains introduced; and the result of this was (especially as corn in this country was generally a little damp) that the flour already ground was, before it escaped, caked together and seriously damaged by the heat and damp combined. The effect of his invention, as he explained it, was to introduce a current of air into the process in such a way as to enable the flour to escape as fast as it was ground, and thus to introduce fresh corn at every turn of the stones, or, in other words, to grind corn "instead of flour." The result, he said, was to avoid a damage to the flour which amounted to between 3*s.* and 4*s.* a quarter, and thus to effect a saving to that amount. He had granted licenses to various millers at the rate of 6*d.* a quarter. The effect of the invention had been found, he said, to be that the English millers were enabled to grind their damp English wheat as well as the French millers were able to grind their dry wheat, and to pass the flour in "dressing it" through gauze as fine as theirs—so fine that there were 150 squares to the inch. The millers, he said, after paying for licences some time, began to infringe his patent and use his invention without paying for it; and he had had to bring several actions to sustain

his rights. He had fitted up (with Mr. Ponsford, a builder) a mill with his apparatus at the cost of about £100,000. The defendants, who were originally millers at Gloucester, had taken licences from him in 1851, soon after his original patent of 1849, at the rate of 2d. a quarter for the whole period then remaining of its duration—that is to say, for twelve years. After its expiration the defendants took the "City Mills," and continued to use his process. About twenty-four of the leading millers opposed the prolongation of the patent. It was renewed, however, and in the meantime the defendants had gone on using his process. They eventually agreed to pay 2*d*. a quarter for the five years' extension of the patent. Some difference, however, had arisen as to the form of the licence to be granted, and in the result they would not accept it, objecting to bind themselves for the whole residue of the term. At the close of Mr. Bovill's examination, a long conference took place between the learned counsel on both sides, the result of which was the settlement of this action and also of the next, which was an action against the same parties for an alleged infringement of the plaintiff's patent—that is, their use of it, after the negotiation had terminated, without his licence.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

Extension of the Factory Acts.—The Government Bill founded upon the report of the Children's Employment Commission proposes to enact that the Factory Acts shall apply to the manufacture of earthenware, except bricks and tiles, not being ornamented tiles; the manufacture of lucifer matches, of percussion caps, of cartridges; the employment of paper-staining, of fustian-cutting, and of finishing, hooking, lapping, making up or packing yarn or cloth of cotton, wool, silk, or flax, or any other materials in shipping warehouses or finishers' works, or those of makers-up and packers. All such factories are to be kept in a cleanly state, and so ventilated as to render harmless, so far as is practicable, any gases, dust, or other impurities generated in the process of manufacture that may be injurious to health. Special rules, to be sanctioned by the Secretary of State, may be made by the manufacturer for compelling, under penalties, the observance by the workmen of the conditions necessary to insure the required cleanliness and ventilation. For the first six months after the passing of the Bill children of not less than eleven years, and for the first thirty months children of not less than twelve, may be employed as young persons exceeding thirteen may under the existing Factory Acts. For the first eighteen months the law against young persons and women remaining during mealtimes in a room where a manufacturing process is carried on, and the law that young persons in a factory shall have the time for meals at the same period of the day, is not to apply to paper-staining or the earthenware manufacture. In a lucifer match factory the meals of young persons or women are not to be taken where any manufacturing process, except that of cutting the wood, is carried on. In fustian-cutting no child under eleven is to be employed, or, as the Bill phrases it, "until the attainment of the age of eleven years."

Patent Office Returns.—The Patent Office vote shows that there were in the past year 3,400 provisional and complete specifications brought in (but only 50 of the latter description), and the fees of the law officers of the Crown in England were £10,363. The fees on patents for the current year are estimated at £105,000, and the expenses at £51,000; so that there will be surplus of about £54,000.

Monster Steam-hammer.—Messrs. R. and W. Morrison, of Newcastle-upon-Tyne, have recently forged one of the largest and most powerful steam-hammers in the world for the Russian Government. The piston-rod to which the hammer is attached is a ponderous piece of metal, weighing no less than 42 tons in its rough forged state; and now, when dressed down to the required dimensions, it has only been reduced to 35 tons. The length of the piston-rod is 58ft., the diameter, 2ft. 4in., having a stroke of 14ft. 6in., the piston being 6ft. 8in. The forging of this mass of metal occupied forty-four days. The cylinder for this hammer was cast at the Elswick Engine Works. Its diameter inside is 6ft. 8in., its weight upwards of 49 tons. The standards weigh nearly 40 tons each. The united weight of the hammer-bar, the cylinders, and standards, amount to over 150 tons.

The Balance Sheet.—The balance sheet of the United Kingdom for the financial year ending March 31, 1864, shows the income of the year to have been as follows:—From Customs and Excise duties, £41,439,000; property, land, assessed taxes, and stamps, £21,619,000; Post-office, £3,810,000; crown lands (net), £305,000; miscellaneous, including nearly £1,200,000 from the revenues of India for British troops serving there, £3,035,963; making a total of £70,208,963; or nearly £400,000 less than in the previous year, taxation having been reduced. The expenditure of the year may be classed thus:—Interest of the debt, £26,211,791; military and naval expenditure, £25,459,647; civil government and pensions, £9,674,809; packet service, £922,082; Scheldt toll redemption, £174,599; Kertch and Yenikale prize money, £85,925; salaries, &c., of the revenue department, £4,527,433; making a total of £67,056,286, or above £2,000,000 less than in the previous year, there being a great reduction in the charge for the army and navy. The surplus shown is £3,152,677, but there was a further expenditure in the year of £800,000, for fortifications. This last sum was raised by the sale of annuities, terminable in 1885; annuities amounting to £55,944 were created, in consideration of sums amounting to £820,000.

Factory Inspectors' Reports.—The usual reports, just laid before Parliament, from the Inspectors of Factories deal with several subjects of great interest. The number of operatives on full time in the cotton districts is stated to have increased by above 60 per cent. in the course of the year 1863, but work was less abundant in the latter part of the year, and the earnings are lamentably insufficient owing to the inferior character of so much of the material. The diminished mortality continues. The improved health of the operatives is attributed to the change to outdoor labour in many instances, less to riotous living in some, and shorter working hours for the women and children. But the diminished supply of nutritious food has begun to tell, and perhaps also the extra labour which Surat cotton entails; and medical men say that the people are thinner and show diminished stamina, and that the constitutional vigour of great numbers is gradually being undermined, though this result is not manifested in increasing sickness but rather in retarding recovery. The report from the schools is satisfactory; the attendance has continued good, and many schoolmasters have kept children in their schools without payment rather than turn them into the streets. The sewing-schools have taught needlework to hundreds of grown-up women who were quite ignorant of it. Mr. Redgrave reports, "I saw a mother, for instance, in a sewing-school, making a frock for her sixth child; this woman had never used a needle until she came to the sewing-class." He gives an account, also, of the improvements which are being effected by the operatives under the Public Works Act. The wages earned at such works have been low, but would improve as the men became accustomed to the work, and they have proved intelligent workers and ready to learn. There has been no backwardness in endeavouring to obtain work in cotton factories; but generally the operatives have been disinclined to leave their neighbourhood, and this feeling has naturally been fostered indirectly by the masters and the house-owners. Mr. Redgrave supposes the cotton imported this year will cost upwards of £80,000,000, but he notices the effect of high price in producing economy. The "waste" from the various processes of the manufacture of cotton is now worked up again, and is the means of giving employment to many hands. The prejudice against the re-manufacture of woollen waste has subsided, and left the "shoddy" trade an important branch of the woollen trade of Yorkshire, giving the consumer cloth of a fair quality at a very moderate price; and doubtless the "cotton waste" trade will be recognised as supplying an admitted want. Cotton mills are still in course of erection; Mr. Redgrave hears that there will be upwards of 100 ready to be worked when the cotton trade revives, and the opinion of the trade is that they will be required and will be worked. Mr. Baker also reports that the mill-owners expect a trade "of which no one has ever yet seen the like." But it is not easy to see where the hands are to be found. To a certain extent the deficiency of labour is likely to be supplied by improvements in machinery. Mr. Redgrave mentions a mill in Manchester in which he noticed new carding engines, and on inquiry learned that 12 are doing the same quantity of work that 75 did before; the manufacturer says he requires 14 fewer hands, and finds a saving in waste amounting to about 10 per cent. in the quantity of cotton consumed. The use of self-acting processes is increasing; in some departments fully a third less hands will be required. The occupier of a large new spinning mill in Manchester says that its arrangements are such as to effect a saving in labour of 10 per cent., and a great saving in power, coal, oil, tallow, shafting, and strapping, and give cheerful rooms and a good atmosphere to breathe. Still Mr. Redgrave has to conclude with the expression of his hope that if a scarcity of hands shall give rise to a demand for an advance in the rate of wages, the warm sympathy which has been so deeply felt by the whole country for the distressed districts, the mutual respect and good feeling which have existed between employer and employed during the last two eventful years, and the experience the operatives have had that the interests of themselves and the masters are identical, will tend to divest the question of wages of all angry feeling, so that it may be settled upon terms which each party may consider as just and fair to the other as to himself.

NAVAL ENGINEERING.

The "Bulldog," 6 gun paddle-sloop, has made her final trial of machinery, at a draught of water of 16ft. 4in. aft, and 14ft. 8in. forward, all stores being on board, and the ship down to her deep sea-going trim. Everything was satisfactory, but it was not considered necessary to put the engines through the ordeal of the measured mile. Their indicated power was 850-horse.

Glass Sheathing for Ships Bottoms.—The iron ship *Buffalo*, having returned to Deptford Dockyard after a three months' trip, was, on the 12th ult., inspected by divers for the examination of Leetch's preservative glass sheathing applied to a portion of her bottom. The result was highly satisfactory, and appeared fully to realise the anticipation of the inventor, as the surface of the sheathing was then as free from any incumbrance as when first laid on.

Naval Expenditure.—The Lords of the Admiralty have sanctioned an expenditure of between £16,000 and £17,000 for new machinery at Chatham Dockyard, the whole of which is to be forwith erected. The new machinery ordered includes a hydraulic press of a new description, and of a size larger than any now in use at either of the royal dockyards, for bending the 6in. and other iron plates, intended for the *Bellerophon* and *Lord Warden* iron-cased frigates. In order to hasten the construction of the *Lord Warden*, the first of Mr. Lee's iron-plated wooden frigates now in frame at Chatham Dockyard, the Lords of the Admiralty propose to give the hands employed on her what is termed "encouragement money," with the view of inducing extra exertions on the part of the workmen.

Trial Trip of the Iron Frigate "Achilles."—The first of the official trials of this frigate took place on the 28th ult., at the Maplin Sands. At the trial the *Achilles* was drawing 22ft. 7in. forward and 23ft. 9in. aft, with the screw immersed 4ft. The total displacement of the frigate was calculated to be 9,500 tons. The wind at the time was blowing moderately from the eastward, with a force of 3, and everything was favourable for the trial. Six runs were first made at full speed, with the following results:—1st run—time, 4min. 45sec.; speed, 12·632 knots; revolutions of engines, 46; pressure of steam, 26; vacuum, 25. 2nd run—time, 3min. 42sec.; speed, 16·216 knots; revolutions of engines; 76; pressure of steam, 25; vacuum, 25. 3rd run—time, 4min. 51sec.; speed, 12·371 knots; revolutions of engines, 46½; pressure of steam, 25½; vacuum, 25½. 4th run—time, 3min. 40sec.; speed, 16·363 knots; revolutions of engines, 47; pressure of steam, 26; vacuum, 25; 5th run—time, 4 min. 49 sec.; speed, 12·456 knots; revolutions of engine, 47; pressure of steam, 26; vacuum, 25; 6th run—time, 3 min. 43 sec.; speed, 16·143 knots; revolutions of engines, 46½; pressure of steam, 26; vacuum, 25. The first means of the above figures give the average speed as 14·424, 14·293, 14·367, 14·409, and 14·299 knots; and the second means 14·358, 14·330, 14·388, and 14·354 knots, the mean of means, or true speed of the ship, being 14·357 knots, or upwards of 16 statute miles per hour. During the trial at full power the frigate carried a rather formidable wave under her bow, but from her form of construction this was thrown off, and offered no impediment to the ship's progress through the water. The water thrown up in her wake was very considerable, owing to the screw not being sufficiently immersed. At the close of the full-boiler trials the vessel's head was laid for the Margate-roads, while five of the boilers were cut off to allow of her being tried at her half-boiler power. This accomplished, the frigate's head was again laid for the Maplin Sands, where two runs were taken over the mile, with the following results:—First run,—time, 5min. 39sec.; speed, 10·619 knots; revolutions of screw, 38; pressure of steam, 25lb.; vacuum, 27½. Second run,—time, 4 min. 34 sec.; speed, 13·138 knots; revolutions, 37; pressure of steam, 23½lb.; vacuum, 27½. The mean speed at half-boiler power was 11·878 knots per hour. During the time she was on her trial, the engines, which are by Messrs. Penn, worked with wonderful smoothness, steadiness, and regularity. At the close of the speed trials some experiments were made

in turning the circles and half-circles with the following results:—The approximate area of the rudder immersed in the water was 135ft.; the time occupied in getting up the rudder, with eight men at the wheel, was, to starboard, 1min. 45secs., to port, 1min. 50secs.; turns of wheel, to starboard, 3½, to port, 3½. The time occupied in making the half-circle at full-boiler power was, to starboard, 3min. 25secs.; to port, 4min. 40secs.; the revolutions of engines were 46. The time occupied in making complete circle at half-boiler power, with 15 men at the wheel, was 6min. 15sec., and the time occupied in getting up the wheel 2min. 30secs. The average temperature during the trial was—On deck, 49 deg.; in engine-room, forepart, 98 deg.; middle part, 107 deg., and aft, 102 deg.; forward stoke-hole, fore-part, 80 deg.; middle, 92 deg.; and after part, 98 deg.; after stoke-hole, fore-part, 76 deg.; middle, 102 deg.; and after-part, 96 deg.

The Steamship "Irresistible," 68 guns, 2,642 tons, which has been recently fitted for the pennant at Sheerness, in the place of the *Dauntless*, 31, was taken from her moorings in the harbour at Sheerness to the Maplin Sands, on the 21st ult., for the trial of her machinery at the measured mile. The engines, which are of 400-horse nominal power, and were built by Messrs. John Penn and Sons, worked most satisfactorily. They were free from hot bearings and priming, and attained an average speed of 8·622 knots at full boiler power, pressure of steam 20lb., vacuum 27, revolutions of engines 64. Two runs were made at half boiler power, giving a mean speed of 7·233 knots, pressure of steam 18lb., vacuum 28, revolutions 54. The draught of water during the trial was 23ft. 7in. forward and 25ft. 3in. aft. The *Irresistible* was fully rigged and had all her stores on hoard. In consequence of the strong easterly wind the speed of the ship was not so great as could otherwise have been obtained.

The "Aurora," 35, screw steam frigate, 400 horse-power, having completed fitting new internal steam pipes at Sheerness, underwent, on the 23rd ult., a trial of her engines previous to her departure to sea. During the trial, an average speed of 10·209 knots per hour was obtained, the pressure of steam being 20lb.; vacuum, 23; revolutions, 61. At half boiler power she made an average of 7·337 knots per hour; revolution of engines, 45; vacuum, 23.

Naval Appointments.—The following appointments have taken place since our last:—R. J. Hay, Chief Engineer, to the *Bombay*; J. Coade, Chief Engineer, to the *Cumberland*, for the *Bristol*; W. B. Stephens, of the *Dart*, promoted to Acting Chief Engineer, and appointed to the *Archer*; E. M'Avory, Engineer, to the *Bombay*; G. Lucas, Engineer, to the *Majestic*; W. Rowley (a), Engineer, to the *Cumberland*, for the *Ætna*; J. Daly, Assist.-Engineer, to the *Bombay*; R. Hetherington, R. Roberts, and Charles Wakeman, Assist.-Engineers, additional, to the *Bombay*; R. Winfield, of the *Dauntless*, promoted to First-class Assist.-Engineer; R. Canney, Chief Engineer to the *Himalaya*; T. H. Symons, Chief Engineer, to the *Indus*, for the *Forth*; J. K. Keay, First-class Assist.-Engineer, to the *Indus*; J. Armable, First-class Assist.-Engineer, and J. A. Cowper, Second-class Assist.-Engineer, to the *Himalaya*; J. Prieble, Second-class Assist.-Engineer, to the *Hector*; C. R. Chamberlain, Chief Engineer, to the *Cumberland*; J. Leeson, of the *Indus*, G. Punnett, of the *Warrior*, J. Warburton, of the *Hector*, and W. Bryan, of the *Hogue*, for the tenders, promoted to First-class Assist.-Engineers; J. R. Hargrave, of the *Rosario*, J. Tapp, of the *Jason*, C. B. Hargrave, of the *Foxhound*, T. Halton, of the *Trident*, and E. Wimshurst, of the *Bacchante*, promoted to Acting First-class Assist.-Engineers; C. Lund, J. Crawford, and L. P. Lewis, supernumeraries of the *Fisgard*, confirmed as First-class Assist.-Engineer; T. E. Butters, Assist. Engineer, to the *Asia*, as supernumerary; J. Franklin, Assist.-Engineer, to the *Victory*, for the *Sprightly*; H. Woolley, in the *Alert*, W. Traill, in the *Jackal*, and R. Brown, in the *Hector*, promoted to be Chief Engineers; E. T. Read, Engineer, to the *Jackal*; P. Gouchy, Engineer, to the *Hector*; R. E. Denison, Engineer, to the *Gladiator*; W. Roberts, Engineer, to the *Indus*; J. A. Kitt, Assist. Engineer, to the *Gladiator*; J. Runnell, Assist.-Engineer, to the *Indus*; J. Oldfield, Engineer, to the *Indus*; D. A. Campbell, J. Leicester, G. Metcalf, and G. R. Bissaker, First-class Assist.-Engineers, to the *Marlborough*, for disposal; C. Lund, First-class Assist.-Engineer, to the *Pembroke*; R. Dixon, First-class Assist.-Engineer, to the *Blenheim*; E. L. Carte, E. J. Whatmore, R. W. Allison, H. G. Haywood, and G. Purkis, Second-class Assist.-Engineers, to the *Marlborough*, for disposal; T. Wilmott, Second-class Assist.-Engineer, to the *Pembroke*; J. Stocks, Second-class Assist.-Engineer, to the *Blenheim*; B. G. Little, Acting Second-class Assist.-Engineer, to the *Majestic*, for the tenders; J. T. Maggs, Acting Second-class Assist.-Engineer, to the *Marlborough*, for disposal.

MILITARY ENGINEERING.

New Principle of Gunnery.—Mr. James Mackay, of Liverpool, has recently invented a new principle of gunnery, which promises to be a dangerous rival to all systems extant. The principle in all rifled cannon appears to have been to allow as little windage as possible, and to make the shot fit the grooves of the piece, taking from them a rotation in its flight. Mr. Mackay, on the other hand, has conceived the plan of having the grooves so arranged that, while the shots fit closely to their outer edge, the grooves are left open for windage. By this arrangement the gas has to travel some feet further than the shot, and in doing this imparts a rapid and perfect "spin" to it. The shots are of cylindrical form, perfectly smooth, with conical heads, and cupped at the other end in proportion, so that each shot is perfectly balanced from the centre of its length. Mr. Mackay in his patent also claims a peculiarity in the wadding, which is of sawdust, by which, at the movement of the first ignition of the powder, the elasticity of the wadding moves forward the shot slightly; the effect is that the whole of the powder is burnt, and the shock on the breech of the gun considerably lessened. A trial of Mr. Mackay's gun has taken place at Crosby, near Liverpool—the target representing a section of the new armour-plated ship *Agincourt*. At a range of 200 yards, a ball weighing 167lb. was thrown, with 30lb. of powder, completely through the target, which it so seriously shattered, that it was rendered completely useless. The outer plate of the target was 5½in. thick; next came 9in. of teak, then an inner plate or skin three-fourths of an inch thick, then angle iron and ribbing, and finally a backing up with timber balks and supports 18in. thick. The shot was picked up 82 yards beyond the target.

Testing of English and French Armour-Plates.—The testing of two 4½in. armour-plates, one of English, and one of French manufacture, on the 8th ult., resulted in the latter proving the better. It may be observed, before referring further to the trial, that the English plate was below the average standard of quality which has been maintained by its makers, Messrs. Beale and Co., for some considerable time past; while the French plate, manufactured by Messrs. Petin and Co., was much above the average standard of the French plates tested in England. Eight inches from the plate's lower edge and in its centre it was struck by the fourth and fifth shots fired full on a bolt. The second shot drove the bolt clear out of the plate into the ship's side, and left the indent in the plate from this double shot 4in. and 7-10ths, a crack being opened up through the indent. Eight inches to the right of these two shots (measuring in each instance from the centre of each blow), and at the same distance from the lower edge of the plate two other shots took effect. They drove that piece on which they immediately struck 14in. into the ship's side (from the outer surface of the plate), and detached a piece of the plate from the main body 2ft. 6in. length by 8in. in depth. The fracture ran through the centre of the indents. The plate had undoubtedly been much shaken by two other shots, which struck immediately above the fracture, although they did not impinge upon the other shot marks. The side of the ship was driven in three inches from its plane at the back of the plate, and the plate itself at its right end was started three inches out from the ship's side. It was a proof of the excellent quality of the metal, however, that a subsequent shot fired at this end of the plate had merely the effect of bending it back into its former position without increasing the damage to the plate's lower centre. The French plate was bolted on the target ship's side by 2in. ordinary iron bolts which started under the blows of the shots, as they usually do. The English plate was attached with Acadian iron bolts, which started in no instance. The history of the introduction (so far as is known to the public) of French plates into this country and their subsequent career is interesting. The first two were supplied by Messrs. Petin, Gaudet, and Co. as "sample" plates, and passed their test in the most successful manner, really deserving all the praise they got. The success of these two plates obtained for Petin, Gaudet, and Co., an order from our Admiralty for plates to the value of about £9,500 sterling, half being of 4½ and the remainder 5½in. On the delivery of these at Portsmouth yard they were at once seen to be of a very inferior manufacture to the "sample" plates, the successful test of which had procured the order. A certain number were, therefore, selected for testing, but not one passed the test laid down by the Admiralty in their contracts, and the whole were reshipped to France with the exception of some three or four which had pieces of their metal cut out as samples for the Iron-plate Committee, and for which, therefore, the makers must be paid at their contract price—£45 and £50 per ton. The two plates tested on this occasion, and two others on the 23rd of March, all of which were from the same plates, have again raised the standard of French manufactured armour-plates.

The Armstrong Guns in Japan.—An officer on hoard the *Euryalus*, writing from Yokohama on the 13th of February, gives the following opinion regarding the value of the Armstrong guns:—"My opinion and also that of the gunnery lieutenant, is that for long range they are most successful. The 100-pounder as a pivot gun is superior to the 95 cwt. solid 8in. gun; but as broadside guns between decks we do not like them; the smoke is too great. Rear choke carriages with such heavy guns are very slow in working and the decks dreadfully cut up. The common shell is one of its great efficiencies, the bursting charge is so great. At Kagosima one vent-piece of the pivot-gun broke and a piece went up to foreyard, but no one was hurt, and it was the fault of the captain of the gun not putting the tin cap in. If the gun is understood and worked properly it is very successful. The 40-pounder we found answer exceedingly well, for coming out of the place we planted common shell, with pillar fuze, wherever we wished, at a range of 3,800 yards. Three steel vent-pieces broke, but another placed them immediately and no harm was done. These guns work very easily, are very true, and the drill is very simple."

STEAM SHIPPING.

The Pacific Steam Route to Australia is to be carried out, the Intercolonial Royal Mail Steam-packet Company having undertaken the contract with the New Zealand and Australian Governments, commencing from Panama. The voyage thence to New Zealand and Sydney is stipulated to be made in thirty-seven days, but is expected to be performed in thirty-five, so as to bring the course of post between Australia and England within four months. By Panama New Zealand is 2,000 miles nearer to England than by the present overland route, and 4,000 miles nearer than by the Cape of Good Hope.

Steam Shipbuilding on the Clyde.—Messrs. Caird, of Greenock, have launched the *Fox*, the second of a new fleet of steamers building upon the Clyde for Messrs. Burns' mail service between Scotland and Ireland. The mail service will be conducted during the ensuing season by the paddle-steamers *Wolf*, *Roe*, *Fox*, and *Lynx*, and by the screw steamer *Beagle*, now building in Messrs. Tod and M'Gregor's yard, and which is to act as a tender to the mail line. Messrs. C. Connell and Co., of Overnewton, have launched a screw of 450 tons named the *Macedon*, which is now being engined at Greenock by Messrs. Caird and Co. Messrs. A. and J. Inglis have completed the *Lady Young*, a paddle, built for the Queensland Steam Navigation Company. The *Lady Young* is of the following dimensions:—Length of keel and fore-rake, 215ft.; beam (moulded), 25ft. 6in. depth, 12ft. Messrs. Inglis are building for the same company a double screwed steamer for coasting purposes, and a saloon steamer for river traffic. The *General Outram* screw, built and engined by Messrs. Blackwood and Gordon, of Port Glasgow, has made a fair trial trip down the Clyde, having "run the lights" in 71 minutes, showing a speed of 11½ knots per hour. The *General Outram* is of the following dimensions:—Length of keel and fore-rake, 155ft.; breadth, 22ft.; depth of hold, 10ft. 6in. Messrs. M'Nab and Co., of Greenock, have launched a screw named the *Emma*, intended for the Nassau trade, and of the annexed dimensions:—Length, 155ft.; breadth, 21ft. 8in. The *Dumbardon*, paddle, built by Messrs. Denny, of Dumbarton, and intended to be employed in the China trade, has been fully completed and equipped.

Screw Steamer for the Viceroy of Egypt.—A new screw steamship, named the *Tantah*, built for the Egyptian Trading Company by Messrs. Richardson and Duck, of Hartlepool, and engined by Messrs. Richardson and Son, of the same town, on the 12th ult., tried her speed at the measured mile in Stoke's Bay prior to her departure for Alexandria. The mean of four runs gave a speed of 12·148 knots per hour; steam, 21lb.; vacuum, 26½in.; revolutions of engines, 67; weights on board, 1,135 tons; draught of water, 15ft. 9in. forward, and 17ft. 8in. aft. The length of the *Tantah* between perpendiculars is 260 3-10ft.; breadth, 33½ft.; depth of hold, 21ft.; tonnage, builders' measurement, 1,445; Custom-house gross tonnage, 1,313 87-100; registered tonnage, 965 89-100. She is propelled by a screw on Mr. Jaffrey's principle, 17ft. 6in. diameter, and 24ft. pitch. The nominal horse-power of the engines is 250; indicated horse-power during the trial 892; diameter of cylinders, 54in., and length of stroke, 3ft.

The "Great Eastern" as a Screw Steamer only.—The *Quarterly Journal of Science* contains an article on "Steam Navigation; its Rise, Progress, and Prospects," by Mr. Martin Samuelson, C.E., in which the author suggests that the paddle engines of the *Great Eastern* should be removed; and in order to show the great advantages she would then possess over other large steamers, he gives the following comparative statement of the capacities of the *Persia* and the *Great Eastern*, under the conditions suggested by him:—"With her paddle engines removed, the *Great Eastern*, would carry about 7,400 tons of measurement goods, and 12,000 tons of coal (more cargo and less coal in proportion.) She would burn about 200 tons of coal per diem, and steam 9 knots per hour. The *Persia* carries, 1,257 tons of measurement goods, and 1,700 tons of coal, and, burning about 150 tons per day, attains an average speed of 12 knots per hour. Thus, if we were to take into consideration the increased speed attained by the *Persia* over the *Great Eastern*, we should have to take the quasi-consumption of the latter, not at 200, hut at 260 tons per day. Now, let us compare the work as it would be performed by the two boats, with the coal required by each, and we shall find that the *Persia*, carrying 1,257 tons of goods, and consuming 150 tons of coal per day, burns 270lbs. of coal per day for every ton of goods carried by her. Whilst the *Great Eastern*, carrying 7,400 tons of goods, and consuming 268 tons of coal per day, would only burn 81lbs. of coal per day, for every ton of goods carried. This comparative statement exhibits in a general manner how great is the advantage of a screw over a paddle steamer for trading purposes, hut as far as the *Great Eastern* is concerned, we do not hesitate to say that with appropriate internal arrangements she could be made to carry at least 10,000 tons of measurement goods; that with the screw alone and a suitable rig, she would, in an average state of the weather, attain a speed of 10 knots an hour; whilst with a good wind she would keep pace with, if not outstrip, the fastest paddle steamer afloat. A comparison of the transatlantic mail paddle boats, supported by a subsidy, with the screw hoats in the same service not so endowed, would further confirm the statement of the superior economy of the screw

Trial of the Double Screw Launch.—The official trial of the double-screw steam launch, which has been constructed and fitted at Chatham Dockyard, as a tender for her

Majesty's screw steamer *Bombay*, took place at Chatham on the 23rd ult. The vessel experimented upon is 42ft. in length, with a breadth of beam of 11ft., and she has been constructed entirely under the supervision of the dockyard officials. Her engines have been manufactured by Messrs. John Penn and Sons. They are nominally of 3 horse-power, but being on the high-pressure principle they can be worked up to ten times that power. The entire machinery occupies a space of 6ft. by 4ft., and the engines are so constructed that the whole machinery can be bodily lifted out of the launch and placed on the deck of the vessel to which she is attached. The weight of the whole is 3 tons 17cwt. 2 qrs. 20lb. There are four cylinders, each with a diameter of 4in., and a length of of stroke of 6in. The connecting rod is 12in. in length, and the diameter 1¼in.; the piston rod is ⅞in. The diameter of the crank axles is 1⅞in.; and the diameter of the screw shaft the same. The screw propeller is 3½ft. in length. The fire-grate is 2ft. by 2ft. and the length of the boiler tubes, of which there are 19, 3ft. 3in., and their external diameter 2½in. The total fire-bar surface is 5ft.; surface of flue, 21ft.; and surface of tubes, 40ft.; the total heating surface is 61ft. The two screws are 4-bladed, and have a diameter 2ft. the set of the pitch being 3ft. 4½in. Each screw is driven by its own independent shafting, which thus enables both to be worked in contrary directions. The quantity of coals on board was 13 cwt. At starting the draught of water, both fore and aft, was 2ft. 6in. The engines were in charge of Mr. Wiggell, from Messrs. Penn's establishment, who superintended their working. Prior to the launch undergoing the most important portion of her day's trials, Captain Stewart directed her to be taken to the most crowded portion of the harbour, in order to test her manœuvring capabilities in and out among the vessels, boats, and other craft about the dockyard. At this time there was a pressure of steam of upwards of 60lb., and the screws each making upwards of 200 revolutions per minute. Before she had been out any great distance it soon became evident that the twin-screw principle enabled a vessel to be almost independent of her rudder. Acting upon this Captain Stewart directed the tiller of the rudder to be removed, and henceforward the vessel was steered solely by her screws. With a strong flood tide running, the vessel was manœuvred by means of her screws with as much ease as when her rudder was brought into use. After fully demonstrating to the officials the steaming and steering capacities of the screw launch, she went alongside the dockyard, where some slight alterations were effected in the machinery, after which the vessel's head was turned down the harbour, and a run taken towards the Nore, during which numerous experiments were made in steering the launch solely by means of her screws, with complete success. The time occupied in the run from Chatham Dockyard to the Camber was two hours, which would give an average speed of rather over six knots per hour. The boat was also tried in making circles, when, with the port screw going ahead at full speed and the star-board screw working astern the circles were made as nearly as possible on a pivot, the average time occupied being 1·247 of a minute with the engines making 310 revolutions per minute. During the run to and fro from the Nore the engines worked with the utmost freedom and regularity, the boilers giving a pressure of 60lb. of steam, the average number of revolutions of the screws being 320 per minute.

The Trial Trip of the Steamship "Washington," built by Messrs. Scott and Co. for the French General Transatlantic Company, the engines supplied by the Greenock Foundry Company, completed her official trial recently, having performed the various requirements of the contract to the entire satisfaction of all concerned. The distance between the Cloch and Cumbrae Lights was performed in 61min. 30sec. against the tide, giving a speed of above 13 knots, the draught of water being 19ft., and the weight of coals on board being about 1,000 tons. The engines are of the side lever construction; diameter of cylinders, 94½in.; length of stroke, 8ft. 8in. The levers are of rolled iron plates 2½in. in thickness manufactured in France, the weight of each lever being 15 tons. The paddle wheels are of the simple radial construction overhung. The steam is supplied by four boilers, with six furnaces in each, arranged in pairs, two before and two abaft the engines, giving a clear fore and aft passage from bulkhead to bulkhead of 85ft.

Cigar Steamers.—The Messrs. Winans are now constructing a cigar steamer on the banks of the Thames at Millwall. The new vessel is 256ft. long, and 16ft. in diameter, with a propeller at each end driven by as great a power as can be got into the vessel. Steam of 150lb. pressure is to be carried, and the estimated speed is 24 miles an hour. This will make the third vessel upon the same general principle which the Messrs. Winans have made since 1859. Since that time Messrs. William L. Winans and Thomas Winans have taken out English patents for an extraordinary number of inventions relating to ships and their machinery, and many of these will be reduced to practice in the new vessel now under construction. Their plan of hull gives very fine lines with the weight well amidships, while the midship section is relatively small to the displacement and the wetted surface is not large.

The Humber Iron Works and Shipbuilding Company.—A prospectus has been issued of the above Company, with a capital of £1,000,000, in shares of £50. The object is to purchase and extend the iron shipbuilding business of Messrs. Martin, Samuelson, and Co., of Hull. The works are to be taken at a valuation, and the goodwill is to be paid for at one year's purchase of the net profits.

The "Baroda."—Some interesting data, illustrative of the continued improvements making in the construction of marine engines, to accomplish the great desideratum of combining a high rate of speed with economy in the consumption of fuel, is afforded by the first voyage to and from Alexandria of the Peninsular Oriental Company's last new screw steamer, the *Baroda*, which arrived on Sunday night. The actual steaming time of the *Baroda* outwards was as follows:—Southampton to Gibraltar, 94¼ hours; Gibraltar to Malta, 81¼ hours; Malta to Alexandria, 68¼ hours; total, 243¾ hours. Homewards: Alexandria to Malta, 76¼ hours; Malta to Gibraltar, 86¼ hours; Gibraltar to Southampton, 113 hours; total, 275½ hours. The voyage out and home was therefore accomplished in 519¼ hours, during which time she consumed 831 tons of coal, and that this marks a great improvement will be seen by a comparison with passages made by three other fast steamers of the company's fleet, viz., the *Delta* (paddle), made the voyage out and home in 550 hours, burning 1,396 tons of coal; the *Malta* (screw), in 505 hours, burning 1,483 tons; and the *Ceylon* (screw), in 546 hours, burning 1,589 tons. The distance from Southampton to Gibraltar is 1,151 miles; Gibraltar to Malta, 981 miles; and Malta to Alexandria, 819 miles; being a total of 2,951 miles, or 592 miles for the voyage out and home.

The British and South American Steam Company.—A prospectus has been issued of this company of a monthly line of screw steamers of 2,200 tons and 500-horse power, from Liverpool and Falmouth to Rio de Janeiro and Montevideo (taking goods and passengers for Buenos Ayres), thence proceeding *viâ* the Straits of Magellan to Valparaiso and Lima. The proposed capital is £1,000,000, half to be first subscribed, in shares of £20, and negotiations for such advantages and facilities as can properly be granted will be opened with the Chilian, Peruvian, Argentine, and Brazilian Governments. The passage time is calculated at 25 days from Falmouth to Rio, calling at Rio, calling at Bahia, at 34 days to Montevideo, 50 to Valparaiso, and 60 to Lima.

LAUNCHES.

The Launch of the "Imperatrice Eugenie," the first of the five steamships building by John Scott at St. Nazaire for the Transatlantic Company took place on the 22nd ult. The Transatlantic Company contracted with the Greenock house of Scott and Co. to build eight paddle-wheel steamers exactly alike, for the lines subventioned by Government between Havre and New York, and between St. Nazaire, Martinique, and Aspinwall. Three vessels are to be built at Greenock and five at St. Nazaire—the latter in a yard specially created for that purpose. The first, built at Greenock, has already arrived at Havre; the *Lafayette* is in dock at Greenock, fitting her engines; and the third is on the stocks. The dimensions of all the vessels are as follows:—Length on deck, 106 metres 50 centimetres; breadth, 13 metres 40 centimetres; depth, 19 metres 60 centimetres; tonnage, old measurement, 3,300; nominal horse-power, 850. Accommodation for 300 passengers; space for 1,400 tons of coal, and for 1,000 tons of cargo.

TELEGRAPHIC ENGINEERING.

The Atlantic Telegraph.—The cable which is now to be tried is one recommended by a committee consisting of Messrs. Whitworth, Fairbairn, Wheatstone, Thompson, and Captain Galston. The committee have also recommended that "during the manufacture by the Gutta Percha Company and by Messrs. Glass, Elliott, and Co. respectively, the conductivity of the copper strand should be determined by the specification of a high standard to be found by the electrical advisers of the company, but not at less than 85 per cent.; that the electrical perfection of the core be determined by the unit system of measurement, and that the standard of the cable should certainly not be below that of the best cable hitherto made that the core of the cable be tested under hydraulic pressure, and at the highest pressure attainable in Reid's tank, now at the Gutta Percha Company's works, that after submission to this pressure the core be carefully examined; also that before it be transferred to Messrs. Glass, Elliott, and Co., it be required to pass the full electrical test under water, that all the tests of the core be made in water of a temperature of 70 deg. Fahr., and after twenty-four hours submersion therein that the company as well as the manufacturers, employ proper persons at the Gutta Percha Company's works to check the electrical tests; and it is desirable that they should arrive at their results by a different process to that employed by the Gutta Percha Company; that the completed cable be continuously tested under water at such temperature as the electrical advisers of the company decide on from time to time, and that the company check the tests; that the joints be tested separately, and that no joint be passed which showed a leakage twice as great as that of a corresponding length of a core; that careful and frequent mechanical tests be made upon the iron wire and hemp, and that the company, as well as the contractors, keep properly paid, and respectable persons on the wire-drawers' premises as well as at Messrs. Glass, Elliot, and Co.'s works, to check the strength and elongation of these materials."

The Persian Gulf Telegraph.—Advices have been received from Sir Charles Bright announcing the entire completion of the Persian Gulf cable on the 27th March. The line was working excellently throughout its whole length. The land line between the head of the gulf and Bagdad is not yet completed.

RAILWAYS.

Railways in New Zealand.—The Moorhouse railway tunnel was lately thrown open to public inspection. The length of the excavation is 2,102ft. A brick lining, five bricks thick, extends the whole length of the soft ground, a distance of about 150 yards. The tunnel was visited by 2,000 persons.

The Social Effects of Railways.—Up to the end of 1834, when not a hundred miles of railway had been opened, the annual average of travellers by coach was some six millions a year; ten years afterwards there were more than four times that number, and at the present moment an average day's work of the railways of the United Kingdom is to carry 500,000 passengers, 258,000 tons of minerals and merchandise, 35,000 live stock, 1,100 dogs, and 740 horses; the aggregate distance run over in the year being 105,141,440 miles.

Railways in Ireland and Scotland.—Last year in Scotland, with a population of 3,000,000, the number of persons who travelled by rail was 17,000,000; whilst, in Ireland, with 5¾ millions, only 10,000,000 travelled. The goods carried in Scotland amounted to 15,000,000 tons, and in Ireland only to 1,500,000 tons.

The Great Eastern Railway Company, for the purposes of their foreign traffic, are about to erect another pier at Harwich. The contract has been taken by Mr. Perry, of Stratford, and the works will be commenced at once.

Railway Wheels for the Prevention of Accidents.—Mr. R. B. Greenwood has taken out a patent for a simple mode of preventing accidents from engines, carriages, or trains running off the line in consequence of obstructions on the rail. The invention consists merely in reversing the middle pair of wheels where six are used, or inserting a middle pair were not used, so that the flanges will run outside the rails while those of the other wheels run inside. The tendency of the old flanges to push the rails out of gauge, too, he considers will thus be obviated, and this cause of trains running off the line removed.

RAILWAY ACCIDENTS.

Accident on the Metropolitan Railway.—On the evening of the 7th ult., an accident attended by no more serious result than a delay of the up-traffic for about three-quarters of an hour, occurred on the Metropolitan Railway, near the King's-cross station. It appears that as the Great Northren train of empty carriages which forms the 6.50 down train from Farringdon-street was passing the points at the King's-cross junction, the break van, from some unexplained cause jumped off the metals, and fell on its side upon the up-Metropolitan line. The disabled carriage was speedily detached, and the train arrived at its destination after a delay of only a few minutes.

BOILER EXPLOSIONS

Manchester Association for the Prevention of Steam Boiler Explosions.—At the monthly meeting of this association, held on the 5th ult., the chief engineer, presented his report, of which the following is an abstract:—During the last month 311 engines have been examined and 418 boilers, 20 of the latter being examined specially and 4 of them tested with hydraulic pressure. Of the 418 boiler examinations, 333 have been external, 11 internal, and 74 thorough. In the boilers examined, 255 defects have been discovered, 4 of them being dangerous. For the present month I have to report 3 explosions, from which 15 lives have been lost, and also 25 persons injured. Not one of the boilers was under the charge of this association. The scene of the explosion has been personally visited in each case, and the cause investigated. The following is the tabular statement:—

Progressive No. for 1864.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
6	Mar. 1.	Vertical Furnace Boiler. Externally fired	12	19	31
7	Mar. 11.	Ordinary Single Flue or Cornish. Internally fired	1	6	7
8	Mar. 22.	Plain Cylindrical Egg-ended. Externally fired	2	0	2
		Total	15	25	40

No. 6 explosion occurred at an ironworks, the boilers of which were not under the inspection of this association. The exploded boiler was of the vertical furnace class, and heated by the flames passing off from three iron furnaces. These flames played in the first instance on the outside of the boiler, then passed through three neck openings into a central internal descending flue, and thence by means of a culvert to the chimney. This is a dangerous class of boiler. It is very inconvenient for complete examination, and the plates at the bottom upon which it sits, may be seriously corroded without detection unless the boiler is lifted from its seat. Also the intense flames from the reverbatory furnaces impinge directly upon the shell externally, and the fires cannot be controlled as in an ordinary grate boiler, while, in addition, from its height and its being enveloped in brickwork, the best arrangement of water gauge becomes inapplicable as well as the fittings generally inconvenient and inaccessible. But not only is this class of boiler from these circumstances peculiarly liable to explosion, but when it occurs, the consequences are peculiarly serious. The boiler standing erect is enveloped in a shell of brickwork some 15 or 20ft. high, and surrounded by three or more furnaces, from the flames passing off from which, it is heated. The temperature of these furnaces is very high, and their fire-brick lining, as well as the masses of iron with which they are charged, is frequently at a glowing white-heat. When the boiler explodes, its brickwork casing as well as the furnaces are demolished, and the debris, much of it red-hot, is showered in every direction, so that more injury is done by the flight of the fragments, than by that of the boiler itself. The boiler in the present instance was 17ft. 4in. high, 9ft. 6in. in diameter, and made of plates three-eighths of an inch in thickness; while the pressure of steam at which the safety valve was loaded appears to have been about 30lb.; a pressure which, the boiler could safely have withstood as long as it was in good condition. An examination of the shell of the boiler after the explosion, left no doubt as to its cause. The boiler was an old one, and had been repeatedly patched; while the edges of the plates where the fracture had taken place were reduced by corrosion for a considerable distance to the thickness of a sheet of paper. The position of the rents was below water line. This corrosion, which had taken place externally at the side of the boiler, as well as at the tippet plate at the bottom on which the boiler was seated, was due to leakage, and must have been going on for a considerable time, while the greater portion of it could have been detected by competent inspection in the external flue. The explosion, in short resulted simply from the dilapidated condition of the boiler. The jury brought in a verdict of manslaughter against the fireman, as well as against the proprietor of the works, and his son, who acted as manager. No. 7 explosion occurred at a saw mill, and was due to the collapse of a furnace flue. The boiler was of Cornish construction, 20ft. in length, and about 4ft. 6in. diameter in the shell. The furnace tube was slightly oval, very likely unintentionally so, through imperfect workmanship, and measured at the furnace mouth 2ft. 6in. vertically, and 2ft. 4½in. horizontally. The thickness of the plates in the shell was three-eighths, and in the furnace tube five-sixteenths of an inch. The furnace tube had collapsed from the fire-bridge to the end of the boiler. These tubes usually collapse vertically, the crown coming down, but in this case the movement had been horizontal, the two sides coming together. The fire-bridge had arrested the collapse at that part, and the crown plates at the furnace end, which showed no signs of having been overheated, remained uninjured. The tube had severed at one of the ring seams of rivets midway between the fire-bridge and the end of the boiler, and the back end plate had been torn away from the shell; while the main portion of the boiler was thrown forwards across the stokehole, and the fragments blown in the opposite direction. It was given in evidence at the inquest, that one of the two safety valves with which the boiler was fitted, was blowing off shortly before the explosion, and on making my examination subsequently, I saw no reason to doubt that the safety valves had been free, though it appeared on inquiry that they had been improperly loaded, as two irregular weights had been allowed instead of a single suitably adjusted one, fixed at the end of the lever. This somewhat complicates the question of pressure, but from calculations founded on such particulars as could be obtained,—the weights having been lost in the general ruin—it appears that the valves were loaded to about 70lb. to the square inch; while it was stated at the inquest, that the blowing off pressure was a little under 40lb. by the gauge; the accuracy and construction of which, however, I was unable to examine, since it had been destroyed by the explosion. The pressure of 70lb., however, would not have been sufficient to injure the cylindrical portion of the shell, neither would it have collapsed the flue tube, had it been well made in the first instance, and strengthened with hoops as it should have been; while even the subsequent addition of supplementary hoops to the flue, in spite of its oval construction, would have prevented the explosion. It is to be regretted that the irregular system of loading the safety valves, referred to above, should have been permitted, still I cannot but consider that the fundamental cause of the explosion was mal-construction of the boiler. The jury brought in a verdict of "accidental death," attributing the explosion to over-pressure of steam consequent on the imperfect condition of the safety valve; appending to their verdict a recommendation to the effect:—That a legislative enactment should be passed, compelling boiler-makers to stamp on their boilers the pressure at which they might safely be worked; and further, that the act should allow none but properly educated and licensed engineers to have charge of engines and boilers, and, in addition, should provide for the periodical examination of all boilers by duly qualified inspectors. No. 8 explosion. This boiler was No. 3 in a series of eight, working side by side, and connected together both by the steam-pipe and feed-pipe. They were of plain cylindrical egg-ended construction, externally fired, and set with a flash flue; their length being 40ft., their diameter 5ft., and thickness of plate three-eighths of an inch. The boiler gave way at one of the transverse seams of rivets situated about 8ft. from the front end, and very near to the fire-bridge. The rent commenced at the bottom, and then continued throughout the entire circle of rivets, severing the shell completely into two sections, which flew in a straight line in opposite directions. Judging from objects struck in its flight, the furnace end of the shell must have assumed a considerable angle of elevation immediately on quitting its seat. Two boilers on each side of the exploded one were dislodged from their original position and thrust laterally. Had not the flue below them been unusually roomy, and thus afforded considerable vent for the steam and water which escaped from the rent, it is more than probable that the explosion would have spread to the sister boilers as it has done in other cases, and perhaps have involved the whole series. This explosion was not due to shortness of water, as an examination of the condition of the plates clearly showed, neither was it due to excessive pressure. It is stated that the ordinary pressure of steam was 52lb., which was by no means dangerously high for boilers of such dimensions, as long as they were in sound condition; while the direction which the fracture took, clearly shows, that the rent was not due to pressure alone. The water with which these boilers were fed was very sedimentary; while they were not fitted with any blow-out apparatus, either at the surface of the water or at the bottom. In consequence of this, the plates over the fire in the exploded boiler had bulged downwards in two places, and repeated repairs had been found necessary to the whole series of boilers at the part immediately over the fire. The seam, however, at which the rent occurred did not exhibit such signs of injury as some of the others, and the fracture, which had run from rivet hole to rivet hole, had not commenced on the outer but on the inner overlap. Several causes no doubt combined to produce this effect, although it may be difficult to determine the exact value of each. The feed was introduced at about the middle of the boiler, and led down to within 9in. of the bottom. This, as has so frequently been pointed out in these reports, should never be done; since it unduly contracts the bottom plates, and the seams are found to give way in consequence. Again, externally fired boilers are frequently weakened by repair; while some are strained by imperfect workmanship in the first instance. To which of these causes the fracture was due, or whether to the whole combined, is neither very easy nor very important to determine. But it is important to note the fact, of an explosion having occurred to an externally fired boiler, from the failure of a single transverse seam of rivets, which neither by leakage nor by any appearance of burning on the outer surface of the plate, gave any warning of danger:—a fact, which it is thought, affords a clear example of the treacherous character of this class of boiler. Having now given the principal facts of the preceding explosions, a few general remarks, in conclusion, may not be out of place. It appears that, during a period of scarcely three months,—*i.e.*, from the commencement of the present year, up to March 25th, the day to which report is made up,—there have occurred eight explosions, from which twenty-nine persons have been killed, and forty-two others injured; while five persons connected with the management of these boilers have been committed for manslaughter. It cannot have escaped attention how extremely simple the causes of all these explosions have been; in three cases, the choking of the feed pipes through frost; in two others, wasting of the plates to the thickness of a sheet of paper; and in the sixth, the mal-construction of the boiler. Ironworks appear to maintain their position at the head of the list, both for the number and fatality of their explosions, and, under these circumstances, it may not be unwise to reconsider the policy now generally adopted at these works, viz.,—that of employing the more primitive description of engineering arrangements, in preference to those of a more modern character, and now widely adopted in other branches of industry. It is often argued that the rough class of labour obtainable at ironworks necessitates the continuance of primitive and rough mechanical appliances; an argument, it is thought, that admits of question. True economy in engineering matters is only to be found in the employment of the best material and workmanship. The continued use of inferior and rough boilers, tends to perpetuate inferior and rough workmen; while, on the other hand, the use of a superior description, would stimulate and raise them; and should the statement which is sometimes made be correct, that ironworks will not supply workmen of the requisite stamp, nothing could be easier than to import them from other departments of engineering. Where boilers of a superior class have been adopted, they have been found to be productive of economy in working, as well as of human life, and there can be no reason to doubt that these advantages would follow their adoption at ironworks. A very frequent source of explosion, and one by no means peculiar to any particular class of works, is that of having no spare boilers, so that the Sunday becomes the only day for examination and repair, when, the time is too short for either to be satisfactorily done, and thus the boilers are worked on in a dangerous state. Apart from other considerations, which need not here be entered upon, the practice of Sunday work is bad engineering. Boilers are injured by being suddenly cooled, and should never either be emptied when hot, or filled with cold water. Examinations and repairs of the plates, if hastily done, are sure to be scamped, and patches temporarily and insecurely hung on with bolts, get to be substituted for soundly riveted plates.

Boiler Explosions.—In the House of Commons, Mr. Ferrand has given notice of his intention to move, on the 3rd inst., for leave to introduce a bill to compensate sufferers from boiler explosions caused by the neglect or default of the owners of the machinery.

DOCKS, HARBOURS, BRIDGES, &c.

Fall of a Bridge.—A road bridge which conveys the traffic between Cambridge and Newmarket, &c., over the Great Eastern line, at a place known as Paper Mills, in the Barnwell suburbs, recently gave way. The bridge, which dates from the formation of the line, is a girder one, with a centre-way for the metals, and two arches on either side, with a centre pier to sustain the girders. It is the pier on the Cambridge side that has given way, having, it appears, been built upon a treacherous galt foundation. The road material fell in a confused heap at the side of the line, but was prevented by the inner pier, which is intact, from intruding on the metals: thus the trains were not impeded.

Galway.—It is stated that the Government has granted a loan for the improvement of Galway Harbour. It is proposed to construct a breakwater connecting Mutton Island with the mainland, upon which a railway will run.

MINES, METALLURGY, &c.

Coal Fields in Brazil.—Mr. Nathaniel Plant, who has been surveying the southern province for the Brazilian Government, in his official report confirms the fact of a valuable and extensive coal field existing there, of which full details were recently laid before the Manchester Geological Society. The locality is on the extreme south, just on the border lands between Brazil and Uruguay, at a distance from the coast in a direct line of about sixty miles, but an extensive shallow lake intervenes, and the sea-board is made up of a vast extent of dangerous sands and low banks. The nearest point to which the coal approaches a port of embarkation is about twenty miles above the mouth of the Jaquaro, so that water carriage exists from the Atlantic port almost up to the coal-fields. The area of the coal-field is conjectured to be about 150 miles square. An engineer is at present surveying the district for the purpose of estimating the cost of a single line of tramway, an item of expense which must be comparatively small in going over a country which is described as being as level as a billiard table. The principal features of this coal-field, as far as it has been examined, consist in the great depth of some of the coal-beds and the facilities which it presents in a long escarpment for getting the coal by open quarrying. A second coal-field lies away some hundred leagues to the north, near Porto Alegre, the capital of the province. A third coal-field has been discovered in the small province of San Catharine lying N.E. of Rio Grande do Sul; it is reported to be a deposit of about 80 square miles, and lying far from the coast in a range of hills. It appears not to be so readily got at, nor is the coal so good and abundant as it is in the greater degree of Candiota. These are the first instances of coal having been found and examined in the great empire of Brazil, with its three millions of square miles of country. It is a most valuable thing to the Brazilian Government, who annually import for gas and steam purposes 250,000 tons of coal at 49s. per ton. It seems to be a bituminous coal and well adapted for steam purposes and smelting; it has also been successfully tested in the Rio gas works. The probability is that this is only the commencement of many discoveries of the kind in Brazil.

Coal in Mont Cenis Tunnel.—At a recent meeting of the Manchester Geological Society, Mr. Joseph Dickinson exhibited a number of specimens taken from the rocks now being tunnelled through the Savoy side of Mont Cenis. They appeared generally to be from metamorphic rocks; and as yet, he believed, no granite had been touched upon. The most interesting mineral is coal, which is found associated with the metamorphic rocks. It has, he was informed, been cut through in different places in the tunnel. Between Saint Michel and Modane similar coal is being worked to supply the district. In thickness it is as irregular as the rocks themselves. It is very similar to the Welsh anthracite. There is no regular dip at all in any of the rocks. In one part they stand up like a cone. As for the coal, it is impossible to say which is the roof and which is the floor, as it is sometimes vertical, and it dips in such a variety of directions. The rock which adjoins the coal is of the nature of shale. There are no stratified rocks near—not more than the bedding sometimes met with in metamorphic rocks; neither is the limestone stratified, but it lies in large masses, the same as quartz. The masses are partially laminated, and the coal lies imperfectly bedded. Here and there the quartz and limestone, instead of taking the shape of solid rock, are like snow or flour, and are used in making the mortar for the tunnel.

Metallic Alloy.—An alloy, described as applicable to the manufacture of all metal articles, bells, hammers, anvils, rails, non-cutting tools, and other articles, has been patented by Mr. H. Micolon, of Paris. The alloy consists of iron, preferably in the form

of waste or ribbons, or of tin and steel, with manganese or borax. He takes 20 parts of iron turnings or tin waste, 80 parts steel, 4 parts manganese, and 4 parts borax; the proportion may be varied. When desired to increase the tenacity of the alloy, two or three parts of wolfram are added. When the cupola is ready he pours in the iron and steel, then the manganese, next the borax, and he re-charges with coke or coal; the metal is thus in direct contact with the fuel in the cupola, and by quickly running the fused mass into moulds, bells which possess the sonority of silver, whilst the cost is less than bronze, may be obtained. When it is desired to give the articles made the appearance of bronze or copper they are electro-coated. When the metal is employed in the manufacture of rails, anvils, &c., it is run over a core of iron. To impart malleability to the alloy he anneals it. The annealing softens the alloy, and allows it to be cut and turned to ornamental and other forms. For edged tools the alloy may be annealed, and then tempered to harden the cutting edge.

Blasting and Electricity.—The United States papers describe an apparatus for blasting by electricity, adopted on the Philadelphia and Reading Railway, as far back as 1859, in widening the tunnels on that line. The battery is described as consisting of about 25 copper cells, 11ft. long by 18in. wide, open at top and bottom, which were set in a wooden frame, and separated from each other by common window glass. Inside of each cell was a plate of zinc, just large enough to allow a slip of grooved wood to hold it away from the copper at the ends. Each zinc plate was connected to the next copper cell, making thus a very large voltaic pile, which was excited by sulphuric acid diluted with about 30 times its weight of water. From each end of this battery an insulated wire ran to the holes to be fired. The frame was arranged to be raised and lowered by a windlass into a wooden trough containing the acid, so that the person engaged in connecting the main wires to those in the holes ran no risk, as the battery was not lowered into the acid until he was at a safe distance. It was found sufficient to insulate one of the wires used for firing by coating it with gutta-percha—the end of the two wires being separated about a quarter of an inch, and connected by a very thin piece of steel wire. Before firing a number of holes were connected together, by taking the protruding end of one wire of the first hole, and twisting it to the end of one of the second, and the remaining one of the second to one of the third.

Indian Coal.—A series of important experiments has been made by the officials of the East India Railway, North-West Provinces, with a view to ascertain the relative value of several kinds of Indian coal. The best results were obtained with the Kurharbalee coal, which evaporated 5·75lbs. of water per pound of coal; next comes the Nerbudda, 5·72; the Singrowlee, 4·95; the Barraka, 4·81; the Raneegunge, 4·51; the Kuryal, 4·29; and the Rajmehal, 2·14. The bad weather prevailing during the trial of the Kurharbalee coal was considered by Mr. P. D. Nicol, the locomotive superintendent, to be equal to 15 per cent. extra work. Mr. J. H. Blackwell, the managing agent of the Nerbudda Coal Company, states that the results of the trials of coal are satisfactory, taking all the items, such as comparative speed and weight of trains, into account. The Nerbudda coal is, in his opinion, superior to any other tried, except the Kurharbalee coal. The apparent superiority of this coal he attributes to some of those accidents common to trials on a small scale, for he is quite satisfied that the Nerbudda coal, upon an average, is quite equal to that of the Kurharbalee field, or any other Indian district. The Barraka coal gets up steam very slowly, and with the Rajmehal coal the steam could not be maintained.

Faulkner's Electric 'Pit Signals.—These signals, the invention of Mr. John Faulkner, of St. Mary's-gate, Manchester, are so constructed as to give the winding signal from the bottom, and return signals from the surface of the shaft, and also for signalling on the levels or inclines by touching the part of the signal constructed, either a greater or lesser number of times, as may be arranged. This will be found to save much inconvenience to men working in the pit. The signals will also be found useful for warning the men to commence or cease work by so many rings of the signal, which will be heard all over the pit; also for signalling all hands in case of danger, or for any other cause. It is also adapted for ventilating doors, to indicate whether they are open or shut. For instance, if a ventilating door which ought to be shut is by neglect left open the signal is so constructed upon a self-acting principle, that it will ring off any hands with a tremendous noise until the door be closed. By a singular arrangement, if a door which ought to be open is by any means closed, the signal will also ring until it be opened. If the door be only opened one-sixteenth of an inch it will set the signal at work with as great a noise as if it were left wide open. In order to show from what part of the mine a signal proceeds, a box or partition may be fixed in some conspicuous place, with a number plate and number for each part of the pit which it may deemed desirable to indicate. These number plates are fixed by hinges so as to move in or out, and the electric wire is fixed to each number plate corresponding with that part of the mine which it represents. Thus when a signal is rung, the number of the part from which it comes is projected outwards. This invention, in fact, may be used for any purpose of warning or calling, or signalling in the pit, and it is to be observed that where any signal is touched it can be distinctly heard all over the mine.

WATER SUPPLY.

Water Supply of Paris.—The two new steam engines at the Quai d'Austerlitz, which increase the supply of the suburban districts of Paris by 4,842,000 gallons of pure water per diem, drawn above the level of Paris, are now fully at work. The engines are 120-horse power each, and are designed to feed two covered reservoirs at Gentilly and Charonne, of a capacity of respectively 1,099,000 and 1,318,800 gallons. From Gentilly, the water is led to Troy, Gentilly, Montrouge, Vaugirard, and Grenelle. The Charonne reservoir supplies Bercy, Charonne, Belleville, la Villette, la Chapelle, Montmartre, and les Bâtignolles. The excess of the two reservoirs is conducted into those of Passy and Chaillot. The object of these reservoirs is, on one hand, to cause the pumping engines, which are single acting, to work at a constant pressure, and, on the other hand, to regulate the distribution of the Seine waters by means of a constant supply, which may amount to 8,154,580 gallons. This capacity is distributed over five compartments, viz., three lower ones, whose timber frame rests on the ground, and two upper ones mounted on two of the lower ones. One of the upper basins is especially devoted to the supply of the Bois de Boulogne, while one of the lower ones is always kept full to serve in cases of fire. The Chaillot engines raise the Seine water through two compression tubes of 2ft. diameter into the Passy reservoirs; the latter find now an additional supply from the engines of the Quai d'Austerlitz. These pumping engines have been designed and executed by Messrs. Farcot and Co., of St. Ouen.

The Dublin Waterworks.—The chief features of the waterworks at Roundwood, are a great storage reservoir, having an area of 400 acres, capable of holding, when filled, 2,482,810,483 gallons of water, or a 200 days' supply for Dublin, 12,000,000 gallons daily; a vast embankment, some 4,600ft. in length; greatest height, 66ft.; the depth of water inside, which will be about 60ft.; and a covered conduit pipe and tunnel, together three miles in length. In the construction of this tunnel, some expected engineering difficulties have been met, in consequence of which the contractor has been allowed a year additional. The embankment is 500ft. wide at the base, and 22ft. at the top. It is a mountain of puddled earth, faced with granite. The cost of the works will be about £280,000; 1,500 men are employed upon them, and it is expected that they will be completed in January, 1865.

GAS SUPPLY.

Water Gas.—Mr. William E. Hagan, a practical chemist, of Troy, New York, United States, has for some years devoted his attention to the solution of the important problem involved in the production of efficient and cheap water gas, and his success is embodied in a new process, which may be seen in operation in an ordinary parlour stove in New York. The water, contained in a boiler on the top of the stove or furnace, may be supplied daily as it usually is to a boiler placed there to maintain a proper humidity in the atmosphere, or by a feed-pipe from a main or reservoir wherever (as in this city) a supply may thus be had. An ordinary stove will consume from three to four gallons per day; and this is conveyed through a pipe on the inner surface of the stove, but avoiding direct contact with the coal or other fuel, till it is emitted, in the form of superheated steam, at the bottom of the fire, where it is decomposed by the contact into hydrogen and carbonic acid gas, which instantly combine afresh, producing carbonic oxide, which undergoes a still further combination or combustion on being presented to the air, with a large development of caloric or heat at each successive stage or combination. Mr. Hagan does not pretend to dispense with carbon or fuel by his invention, but to economize its use to the last degree. In other words, instead of allowing half the carbon to escape in the form of carbonic acid, he consumes it entirely, leaving nothing to escape as smoke but water, and perhaps a little ammonia. He thus reduces the consumption of carbon or coal one half, while maintaining a more temperate and equable combustion with a steadier and more healthful heat. The atmosphere of apartments or houses heated by his stoves or furnaces is more bland and summer-like than any other process of combustion can supply. The process is by no means expensive—adding perhaps one-third to the cost of a stove, and one-tenth to that of a furnace.

The Sheppy Gas Consumers' Co., Sheerness, have declared a dividend after the rates of 4 and 5 per cent. per annum on two classes of preference shares respectively, and a dividend of 10 per cent. per annum on all ordinary shares paid up on the last day of that year. The directors contemplate reducing the price of gas now charged at 5s. per 1,000 cubic feet, at the end of the present year.

Position of Gas Companies.—In evidence given before the committee sitting on the Birmingham Gas Companies' Bill, the following statistics with regard to the present position of gas companies was quoted. The metropolis has thirteen companies, with a gross capital of £5,272,279, and a gross revenue of £1,836,946. The meter rental of the thirteen companies is £17,330; the gas expenditure, £1,333,305; the annual reserve, £32 506; the cost of coals, £707,783; and the residual product, £310,173. The price at which the gas is sold varies from 4s. 6d. to 6s. per thousand feet, and the average dividend paid by the companies is 10 per cent. The Liverpool United Gas Company has a shareholders' capital of £529,900, a gross revenue of £204,393, a meter rental of £10,279, and a gas expenditure of £137,562. The price charged for gas varies from 3s. 5d. to 3s. 9d., and the dividend paid is 10 per cent. The Manchester Corporation Gas Works has a shareholders' capital of £397,430, a gross revenue of £161,416, a meter rental of £244, and a gas expenditure of £106,570, exclusive of depreciation. The price charged for gas is 3s. 9d. and the amount of the annual reserve, £12,179. The Bristol Gas Light Company has a shareholders' capital of £24,000, a gross revenue of £68,046, a meter rental of £1,466, and a gas expenditure of £51,406. The price charged for gas is 3s. 9d., and the amount of the annual reserve £2,000. The Wolverhampton Gas Company has a shareholders' capital of £81,168, a gross revenue of £25,902, and a gas expenditure of £1,741. The dividend paid is 10 per cent., and the amount of the annual reserve £750. The Birmingham Gas Light and Coke Company has a shareholders' capital of £211,700, a gross revenue of £87,330, and a gas expenditure of £70,985. The price charged for gas is 3s. 4d. and 2s. 8d. The Birmingham and Staffordshire Gas Light Company has a shareholders' capital of £357,900 a gross revenue of £147,228, and a gas expenditure of £107,447. The price charged for gas is 3s. 4d. and 2s. 9d.

Continental Union Gas Company.—A prospectus has been issued of the Continental Union Gas Company, with a capital of £400,000, in shares of £20, to carry on and extend the business of gasworks now in full operrtion, with exclusive privileges at several of the principal towns of France and Italy, including Strabourg, Cette, Nimes, Milan, Genoa, Parma, Modena, and Alessandria. These works belong to a society called the "Union des Gaz," and are to be held by the present company under lease for twenty years, when the company will share with the Union des Gaz the entire possession of the property. The directors and auditors are all persons of the highest experience in this department of enterprise, and the calculation is that by bringing the best modern system to bear upon the working of the undertaking the receipts may year by year be augmented in an almost uninterrupted proportion. The brokers are Messrs. Hill, Fawcett, and Hill, who have also been long connected with leading gas companies.

APPLIED CHEMISTRY.

On the Preparation of Green Colour without Arsenic, by Dr. Elsner.—Having recently had occasion to study a pulverulent green colouring matter which he had been requested to analyse, and which was called green cinnibar, the author found that this matter, all shades of which could be obtained from the lightest to the darkest, contained various proportions of Prussian blue and chromium green. This colour, applicable to the manufacture of paper-hangings, will not serve for painting walls containing lime, as its action alters the tint of the Prussian blue. Neither will it serve for colouring bonbons or for any other culinary purposes, because, though it contains no arsenic, it is not free from hurtful qualities. The following are the directions for obtaining the different shades:—Make a solution of yellow chromate of potash and another of yellow prussiate of pottash, then mix the two. Dissolve separately in water some acetate of lead and iron, and add this solution to the others. By precipitating the first two solutions by the third a green deposit is obtained, the tint depending on the proportions employed. It is scarcely necessary to say that the larger the quantity of acetate of lead and chromate of potash, the lighter the shade obtained. Wash the precipitate carefully and dry it with gentle heat. The necessary acetate of iron may be obtained in various ways, especially by precipitating a solution of acetate of lead by sulphate of iron and filtering the supernatant liquid.

On the Preparation of Iodine of Ammonium, by Dr. Jacobsen.—The author dissolves equivalent weights of pure iodide of potassium and pure sulphate of ammonia in the smallest possible quantity of boiling distilled water. One part of sulphate of ammonia will require about one and one-third of its weight, and iodide of potassium about half its weight of boiling water for solution. The two solutions are then mixed and well stirred. After the mixture has cooled, water containing 15 per cent. of alcohol is added, and the whole is allowed to stand twelve hours. In very cold weather less alcohol will suffice to separate the sulphate of potash formed. According to Schiff, 100 parts of water and 10 parts of alcohol at 15° C. only dissolve 3·9 parts of sulphate of potash. The iodide of ammonium, in consequence of its greater solubility, remains in the solution, which is now drained from the precipitated sulphate of potash, filtered, and evaporated until a pellicle forms. As the solution is very concentrated, the evaporation is quickly effected. After the crystals of iodide of ammonium are formed, they are drained from the mother liquor, which, together with the residue of sulphate of potash, is again treated with dilute alcohol, and the liquor evaporated for a further yield of sufficiently pure iodide. Care must be taken to exclude all acid vapours from the chamber in which the evaporation is carried on; and it is well to add to the solution from time to time a few drops of ammoniated alcohol.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent, Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated March 23rd, 1864.

734 W. Routledge & F. F. Ommanney—Presses for packing cotton
735 W. Forgie—Preparing materials for the manufacture of boots and shoes
736 T. H. Head & H. Smith—Improvements in mouldings
737 J. Strafford—Roof lamps of railway and other carriages
738 W. Leuty — Self-acting saddle for wet flax spinning frames
739 F. Tyerman—Apparatus to be used in combination with parts of gas and lamp fittings
740 G. Couchman—Fastenings for stocks and neckties

Dated March 24th, 1864.

741 J. Edis—Fastening table tops
742 J. & J. Wild—Preparing and spinning wool and other fibrous substances
743 R. H. Wright—Construction and arrangement for condensing by external surface the steam used in marine steam engines
744 E. Leak—Conducting messages, sounds, or signals from one place to another
745 C. Garton & T. Hill—Improvements in mashing apparatus
746 S. Bark, T. Attwood, & J. D. Robinson—Slides for gasaliers
747 J. T. Stroud—Lamps
748 W. E. Gedge—Aerial machine
749 A. Blonin & N. D. Mercier—Unserrate axle tree with levers
750 W. Roberts—Improvements in traction and hauling engines
751 I. Barnes—Gasaliers and gas brackets
752 S. Mathews — Breech-loading fire-arms and cartridges
753 W. A. Torrey—Lubricating the axles of railway carriages

Dated March 26th, 1864.

754 R. A. Brooman — Apparatus for revivifying animal black
755 V. Dubourg—Gas burners
756 W. Clark—Hats
757 A. Staples—Machinery for combing wool and other fibres
758 T. W. Rammell — Pneumatic railways and tubes
759 J. Warburton — Preparing silk and other waste
760 G. T. Bousfield—Revolver fire-arms
761 M. Clough — Improvements in reefing and stowing sails
762 E. Lever—Fixing hoops in the interior of flexible tubing employed in the ventilation of mines and other similar purposes
763 J. Symes—Locomotive apparatus applicable to land and sea

Dated March 28th, 1864.

764 E. Hill—Armour plates
765 W. Kirrage—Breech-loading cannon
766 E. Pace—Placing splints and other like articles for the manufacture of matches
767 C. Hartley—Looms for weaving
768 J. Coulter & J. A. Barber—Tentering, stretching, and drying woollen fabrics
769 J. Lightfoot — Dyeing and printing textile fabrics and yarns
770 M. Henry—Supplying air to persons employed under water
771 M. Scott—Ships or vessels
772 J. Rees—Preservation of ships, life, and property at sea

Dated March 29th, 1864.

773 J. Robbins—Treating liquid and solid substances
774 T. B. Harpur—Representing musical characters and notes so as to facilitate the reading off of any musical composition.
775 I. M. Evans—Improvements in blasting for mining and other purposes
776 E. Grether—Carding engines
777 S. Harrison & W. Clements—Improvements in fire grates
778 T. Bradford—Churning and butter making machines
779 W. E Newton—Hulling grain
780 H. Holden & E. S. Forshaw — Looms for weaving
781 W. Arthur—Compasses
782 A. Heald—Composition for sizing yarns and threads
783 C. Doughty—Treating a product obtained in refining the oil of cotton seeds
784 H. Smith & E. Roberts—Breaking stones and minerals
785 S. Trotman—Self extinguishing candle lamps

Dated March 30th, 1864.

786 J. Lang—Ventilating mines
787 D. Treadwell—Constructing hoops to be used in the manufacture of cannon
788 T. Allan—Looms for weaving
789 H. A. Bonneville—Railways
790 T. Waller—Heating air
791 T. J. Smith—Purification, distillation, rectification, evaporation, condensation, concentration, and oxygenation of spirits
792 R. Douglas—Combs and brushes
793 J. Williamson—Leather cloth, oiled table covers, and other oiled fabrics
794 R. Douglas—Rotatory hair brushes
795 W. E. Newton—Apparatus for boring rocks or hard substances
796 R. Ferguson & W Lattimer—Finishing textile fabrics
797 H. Bayley, L Newton, & J. Greaves—Turning, boring, cutting, shaping, and reducing wood and other substances

Dated March 31st, 1864.

798 W. Martin & J. Hodgson—Improvements in steam engines
799 M. Kurts—Making and applying an almanack or a thermometer to the handles of walking sticks and umbrella handles
800 J. P Ferris & K. H. Cornish—Signalling by means of fluid pressure
801 J. G. Beckton—Forcing, blowing, or exhausting air and other gaseous fluids
802 J. Prestwich & W. Brooks—Frames used in preparing cotton
803 H. H. Mills—Constructing the joints for iron or steel plates
804 W. Holbrook—Hair brushing
805 W. Holbrook—Window sashes
806 R. A. Brooman—Gas generating apparatus

Dated April 1st, 1864.

807 E. Stott—Rails for railways
808 J. Bickerton—Engines for carding cotton and other fibrous materials
809 J. Hicks—Improved maximum mercurial thermometer
810 J. Bullough—Looms for weaving
811 J. Greenwood—Preparing and spinning fibrous materials
812 A. Prince—Generating steam
813 E. Ambrose—Umbrellas
814 T. Coltman—Circular knitting machines
815 W. E. Newton—Looms for weaving hats and other articles of irregular shape
816 C. Sanderson—Armour plates
817 J. J. Lundy & R. Irvine—Paper
818 A. Macrae—Tilling and cultivating land

Dated April 2nd, 1864.

819 S. W. Silver — Extracting the juice of the sapota mulieri or bullet tree
820 S. W. Silver—Preparation of the milk gum or juice of the sapota mulieri or bullet tree
821 J. Hunt—Instrument for registering the time of arrival and departure of work people in houses of business and manufactories
822 J. Capper—Curing smoky chimnies
823 J. Walker—Working guns
824 The Hon. J. T. Fitzmaurice—Improvements in rudders
825 E. Lindner — Springs for railway carriages and buffers
826 W. Cullcott—Apparatus for producing scenic effects
827 R. J. Edwards—Toughening papers and other substances to render them suitable for the application of fibraceous substances
828 E. U Parod—Feeding steam generators
829 F. Potts & A. H. Green—Improved combination easel
830 T. H. Head—Reservoirs
831 T. Richard—Apparatus for warming and ventilating
832 C. D. Tisdale—Railways and railway carriages
833 W. E. Newton—Electric or telegraphic conductors

Dated April 4th, 1864.

834 L. Cooke—Paper
835 T. Briggs—Pumping water out of mines and other places
836 G. R. Stephenson—Levelling for and forming foundations either under or above water
837 J Smith—Looms for weaving cords and other fabrics
838 T Brown—Military and other knapsacks
839 T. Bourne—Cotton gins
840 W. E. Newton—Paddle wheels

Dated April 5th, 1864.

841 S. Martin & E. Young—Manufacture and application of fire-resisting cements and materials
842 E. K. Dutton—Covering the surfaces of rollers or cylinders
843 N. Sarony—Photography
844 J. Roberts—Chains for cables, coupling irons, and other purposes
845 J. N Douglass—Framing lighthouses, hollow metal piles, and cylinders
846 M. J. Roberts—Preparing, spinning, twisting, and doubling wool and cotton
847 A. McLaine—Construction and ventilation of ships and vessels
848 R. A. Brooman—Artificial fuel
849 G. B. Cornish—Applying copper, yellow metal, or other metal sheathing to iron ships and other navigable vessels built of iron
850 J Platt, E. Spencer, & J. Dodd—Mules for spinning and doubling cotton
851 W. Clark—Cartridges boxes and percussion cap pouches
852 J. H. Johnson—Stoking shovels

Dated April 6th, 1864.

853 E. D. Chattaway—Railway signals
854 D. Stewart—Calendering, mangling, or finishing
855 W. Clark—Oil cans
856 E. T. Hughes—Registering the quantity and quality of alcohol obtained in distilleries
857 J. Lightfoot—Sizing textile fabrics and yarns
858 J. Nichols—Looms for weaving
859 E. T. Hughes—Manufacture of printed woollen velvets or plushes
860 H. G. Fuller—Mechanism applicable to the general purposes of propulsion
861 W. T. C. Pratt—Enabling the points on railways to be shifted and signals worked by an attendant in the train while the train is in motion
862 G Smith—Rotatory engines
863 J. H. Johnson—Permanent way of railways
864 R. Douglas — Apparatus to be used in hair cutting

Dated April 7th, 1864.

865 J. F Sharp—Trap for gullies, sinks, and drains generally
866 W. Hul—Breech-loading fire-arms
867 F. Weintraud—Ornamenting steel and wrought iron
868 C. J. L. Leffler—Pulverising minerals and other substances
869 J. Snider—Breech-loading ordnance and projectiles
870 E. Aldis—Production of a new light
871 W. B. Adams—Construction and propulsion of vessels
872 H. A. Bonneville — Cleaning tubular steam boilers
873 J. H. Johnson—Crinolines
874 A. Rigg—Propelling vessels
875 C. Beard — Glazing horticultural and other structures
876 J. S. Richardson—Preparing the carcases of pigs and other animals for curing

Dated April 8th, 1864.

877 J. Picking — Refrigerating wort and other liquids
878 D. Moseley—Cloths
879 J. Lascelles—Regulating the flow and surface level of water from reservoirs
880 C. A. & T. Ferguson—Checking the recoil of gun carriages
881 N. Wood & J. Stockley—Grinding, smoothing, and polishing plate glass
882 E. Pratt—Portmanteaus, boxes, or travelling cases
883 F. C. Goodwin—Sights for small arms and ordnance
884 J. B. Fenby—Buckles
885 J. Lloyd—Puddling iron
886 R. Thatcher—Lubricating machinery
887 W. Clark—Preparing vegetable fibrous materials
888 T. S. Martin—Cutting, shaping, and ornamenting wood, ivory, or other materials
889 A. Rodger—Rotatory pumps
890 M. Simpson—Covering elastic strands
891 J. Jordan—Surface condensers

Dated April 9th, 1864.

892 J. Howell—Hammering and planishing metal plates
893 J. H. Simpson—Printing from type by electricity
894 M. Benson—Pumps
895 J. Nisbet—Cutting minerals
896 J Dodge — Rolling, shaping, and forging metals
897 A. B. Brown—Raising weights
898 B. X. Richard & R. Radisson—Gold and silver wire
899 J. B. Thompson—Electro-magnetic induction machines

Dated April 11th, 1864.

900 E. Dronke—Gunpowder
901 T. G. Miller—Washing, cleansing, and drying grain
902 A. T. Becks—Furnaces for steam boilers
903 A. Smith—Lamps
904 W. E. Gedge—Condensing steam
905 T. C. Jones—Ships' anchors
906 M. Todd—Combing wool or other fibrous substances
907 A. Earnshaw—Connecting rails for railways
908 J. Ferrier—Preparing jute and other fibrous substances

Dated April 12th, 1864.

909 M. A. F. Mennons—Applying pressure to the rolling and drawing of metals
910 F. A. P. Pigou—Powder flasks
911 F. G. Piemont—Oiling the axletrees of railway carriages
912 R. A. Kemp—Tuning pianofortes
913 T. Chamberlayne—Connecting railway engines
914 J. Lillie—Taps
915 M. L. Peters & W. Harkes — Mowing and reaping
916 J B. Alliott—Ploughs
917 W. Clark—Motive power
918 A. J. Fraser & F. Squire—Punching vamps and toe caps
919 W. Gadd—Looped fabrics
920 H. & J. W. Lea—Securing the lids of coal cellar holes
921 W. N. Wilson—Sewing, stitching, and embroidering
922 H. Charles—Buttons
923 W. E. Newton—Stop cocks

Dated April 13th, 1864.

924 J. C. Rohrbeck—Chaff cutting machine
925 F. A. Gatty—Treating garancine and other products of madder
926 A. Audiger—Embalming dead bodies
927 W. Reading—Fastenings for attaching watches
928 J. C. Evans & J. C. Thompson—Preserving the bottoms of ships
929 J. Burchall & E. Borrows—Arming war vessels
930 A. S. Stocker, R. Gold, & A. R. Stocker—Hinges
931 J. Neilson & J. Gillies—Closing capsules on bottles
932 T. W. Miller—Motive power engines
933 T. R Crampton—Bricks
934 J. Cope—Steam ploughing

Dated April 14th, 1864.

935 P. A. L. de Fontainemoreau—Musical instruments
936 J. Bullough—Looms for weaving
937 T. Steven & C. Batey—Ventilating
938 Y. Meirat—Propelling vessels
939 F. Browett—Embroidered trimmings
940 J McElroy—Electric telegraph apparatus
941 H. Higgins—Cleaning cotton
942 S. Moore—Removing heavy bodies
943 G. A. Tremeschini—Lamps
944 W. Symons—Lighting railway carriages

Dated April 15th, 1864.

945 A. R. Le M de Normandy—Ships' hearths
946 A. H. A. Duraut & W. H. P. Gore—Carriages
947 T L. Scowen—Tri-expanding canopy
948 W. & W. Ovenden—Preventing doors and casement windows from slamming or clapping
949 J. Milnes—Fuel
950 G. W. Rendel—Checking the recoil of gun carriages
951 E. Rowing—Steam engines and boilers
952 C. Doughty & W. D. Key—Treating a product obtained in refining the oil of cotton seeds
953 J. H. Johnson—Metallic capsules
954 W. Clark—Ships or vessels
955 J. C. Coombe—Fertilising agents for agriculture

Dated April 16th, 1864.

956 H. B. Barlow—Valves for steam engines
957 C. H. Prosser—Cleaning tobacco pipes
958 J. A. Nicholson—Watercloset apparatus
959 W. Clark—Preservation of animal matters
960 A. Priest & W. Woolnough—Hoeing land
961 W. Payton—Measuring liquids
962 W. E. Gedge—Sorting cereals
963 M. B. Cooper—Rotatory engines
964 J. Riley—Sizing substance
965 A. V. Newton—Cerealine
966 G Haseltine—Metallic nuts
967 W. Ehrhardt—Keyless watches
968 A. W. Smith—Pegs and rivets
969 R. Midgley—Combing wool

Dated April 18th, 1864.

970 M Guthrie—Printed checks
971 W. E. Gedge—Power loom for weaving
972 J. H. Johnson—Obtaining motive power
973 J. C. A. Henderson—Ladies' skirts
974 G. Davies—Respiratory apparatus
975 J. Stevens—Drying paper

Dated April 19th, 1864.

976 J. E. Spratt—Fastening for gates and doors
977 G Burstall—Treating cotton seed
978 G. T. Bousfield—Presses
979 J. Edis—Fastening table tops

Dated April 20th, 1864.

980 J Shaw—Iron caissons
981 H. Levinstein—Purple violet and blue dyes
982 W. G. Cooper & J. Fletcher—Looms.
983 J. Briere—Self acting condenser
984 G. Green—Ornamenting plated wares
985 J. Head—Foundations for heavy structures
986 S. S. Robson—Ropes and cordage
987 S. Harrison & W. Clements—Fire grates
988 J H. Johnson—Puddling furnaces
989 J. P. Harriss—Projectiles
990 A. C. Fraser—Gas
991 W. E. Newton—Equilibrium slide valve
992 A. V. Newton—Pianoforte

Dated April 21st, 1864.

993 Dr. H. Lomer—Obtaining motive power
994 J. Standeven—Self-acting mules
995 J. Armstrong—Steam hammers
996 H. Wadkin—Working points and signals of railways
997 W. Clark—Pens
998 J. Abraham—Machinery for coining
999 H. A. Bonneville—Product obtained by concentrating the saponaceous parts of the quillai tree
1000 H. A. Bonneville—Photographic apparatus
1001 H. A. Bonneville—Making artificial leather
1002 J. Jones—Moulding clays, earths, and other like materials
1003 G. P. Wheeler — Grinding and polishing metal
1004 L. Thomas—Lifting battery
1005 J. G. Jennings—Caissons and coffer dams
1006 J. G. Rollins—Cotton gins
1007 J. G Jennings and M. L. J. Lavater—Pumps
1008 A. Leighton—Stamps and other printing surfaces in relief
1009 F. Potts and C. Harvey—Ornamental bricks
1010 B. W. A Sleigh—Applying motive power

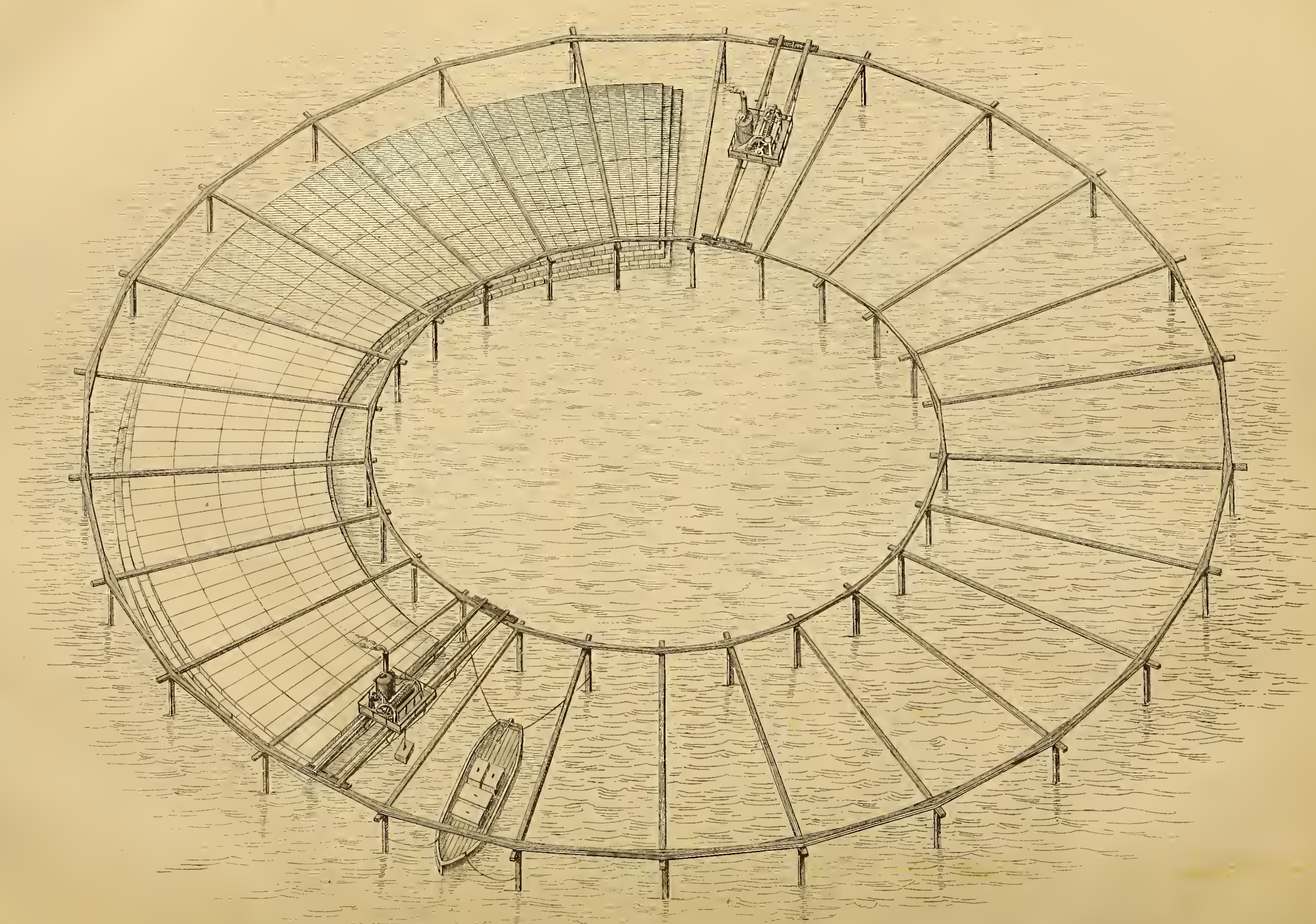
Dated April 22nd, 1864.

1011 T. Pepper—Boot and knife cleaning machine
1012 G. Davies—Inhaling apparatus
1013 J. R. Croskey—Paying out submarine electric telegraph cables
1014 J. C. Rivett—Lubricators
1015 W. Clark—Pulleys and riggers
1016 W. L. Barnes—Fastening for garments
1017 G. F. Harrington—Drilling, cutting, grinding, and polishing teeth whilst in the mouth
1018 J. Thompson—Hollow axles and axle boxes
1019 J. E. Duyck—Distilling and purifying petroleum oils
1020 S. F. Feldman—Boots
1021 J. E. Duyck—Treating petroleum
1022 A. V. Newton—Rotary engine
1023 W. E. Newton — Supporting vessels while undergoing repair

Dated April 23rd, 1864.

1024 G. J. Worssam—Expressing liquids or moisture from substances
1025 E. S. Simon—Combined collar and necktie
1026 T. P. Tregaskis—Raising and forcing fluids
1027 A. Wardle—Smoking pipes
1028 D. Lewis—College caps
1029 D. Hussey—Looms for weaving
1030 J. M. Pratt—Brick making machine

BIRD'S EYE VIEW OF SMITH'S RADIAL TRAVERSING CARRIAGE
AS ADAPTED FOR THE SPITHEAD FORTS.



W. Smith, C.E. direx

RADIAL TRAVERSING CARRIAGE

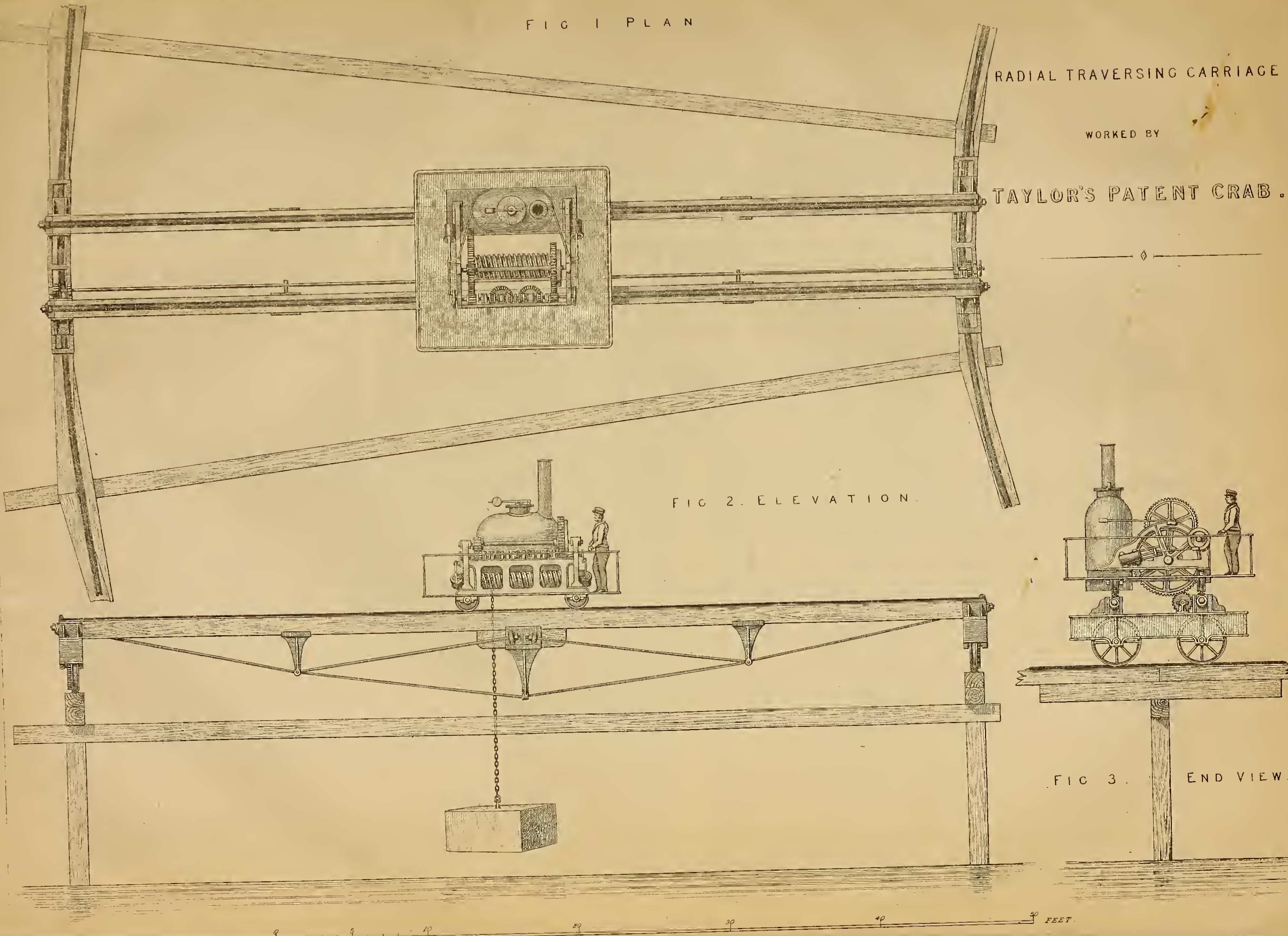
WORKED BY

TAYLOR'S PATENT CRAB.

FIG 1 PLAN

FIG 2. ELEVATION.

FIG 3. END VIEW.



THE ARTIZAN.

No. 18.—Vol. 2.—Third Series.

JUNE 1st, 1864.

E. P. SMITH'S PATENT RADIAL TRAVERSING CARRIAGE WORKED BY TAYLOR'S PATENT STEAM CRAB.

(*Illustrated by Plates* 261 *and* 262.)

The radial transversing frame or carriage, the subject of the accompanying plates 261 and 262, was invented by Mr. E. P. Smith, whilst superintending for the contractor, the works in course of construction at the Portland Breakwater. The nature of the design for the pier head at the end of the breakwater, necessitating the employment of some special contrivance adapted for the ready depositing of the tipping or rubble required for the substructure of the foundations of the pier head, which consists of a ring of masonry about 220ft. in external diameter at the level of the foundations, which were about 50ft. wide, and at the level of 20ft. below low water, on a bank of rubble stone or pierre perdue 40ft. in height, the quantity of stone, with the necessary slopes required for this being about 120,000 tons.

In order to insure a perfect homogeneousness of the substructure it was specified by the engineer of the work that the tipping or pierre perdue should be evenly distributed or tipped over the whole area of the space covered by the masonry, and as a circular disposition of stage would conform best to the arrangement of the structure it was evident that, were such erected, a pair of girders on end frames, moving on wheels whose axles radiated to the centre of the circular railway or gantry, would admit of the trucks containing the stone being run upon the frame, traversed to any point within the circular ring and tipping.

A necessary part of this arrangement was the providing of a means to enable the girder or radial traversing frame to retain its proper radiation in every position. This was obtained by means of a lying shaft, and a train of gearing at each end connected with the driving wheels of the frame, so arranged that the speed of the peripheries of the same should be proportioned to the relative diameters of the outer and inner circles.

This first adaptation of the invention was very successful. The girders were 65ft. long, the circles 112 and 224ft. in diameter respectively, and the frame was traversed by a four horse-power engine fixed upon it. The quantity of 120,000 tons was tipped in twelve months, or at the rate of 400 tons a day on the average; that, however, included all delays from accidental circumstances so that the quantity of deposit when in full work did not fall short of 600 tons a day.

It is scarcely probable that the invention will be made applicable for a similar use again, but it is not at all unlikely that a traverse frame, turning on circular rails, might be useful in many situations such as railway stations, where irregularly shaped or angular spaces of great commercial value are desired to be made use of.

The invention was next applied to the overhead travellers used at the same site for the setting of the block masonry above alluded to. In this adaptation it proved eminently successful; patent steam crabs made by James Taylor and Co., of Birkenhead, being the motive power. The blocks of stone varied in weight from 1 to 7 tons, averaging 2½ tons, and the arrangements were such that 400,000 cubic feet were set below water by the use of three of these machines in one twelvemonth.

The radial arrangement coupled with the large span of the travellers enabled the whole of the masonry to be set without building in any of the temporary props or involving the necessity of the removal of any of them.

The crabs were made to execute three several motions—to hoist and lower the weight, to move the travellers each way in a circular direction, and the crab along the traveller forwards and backwards radially, any of which could be brought into play without stopping any other that might be in motion.

One of these crabs, now in operation at the works of the Spithead Forts, has frequently lifted and landed, 20 blocks weighing 5 tons each within the hour, being at the rate of 1,000 tons a day.

Others, manufactured at the Britannia Works, Birkenhead, are to be seen in operation in the construction of the Thames Embankment by Mr. Furness, and also on the works of the Mersey Docks and Harbour Board, Liverpool, where they are being largely used by the eminent engineer for that estate.

We purpose giving in a future issue a plate devoted to the illustration in detail of the steam crab, specially designed and constructed by Mr. Taylor for such works as those we have alluded to.

THE WINAN'S YACHT.

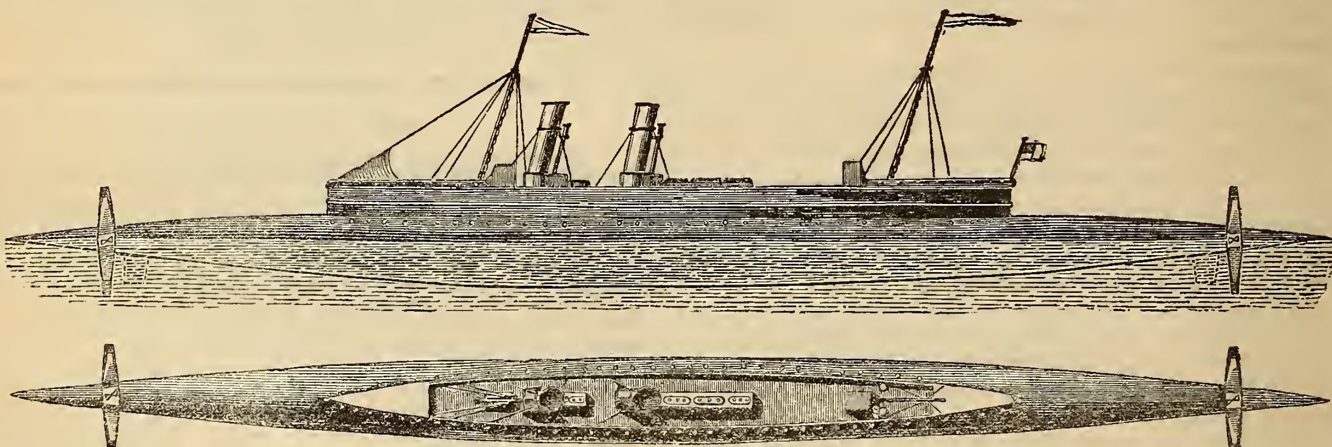
The annexed engraving illustrates a yacht which is being built at the shipyard of Mr. John Hepworth, Cubitt's Town, Isle of Dogs, by Messrs. T. and W. L. Winans. The engines are being constructed by Messrs. Jackson and Watkins, of the Canal Ironworks, Millwall, Poplar. The length is 256ft.; breadth, 16ft.; depth, 16ft.; deep displacement, 500 tons. The transverse section of the hull is a perfect circle in every part of its length, and longitudinally represents the arcs of a circle of 1,028ft. radius. The length of the hull, in proportion to its beam, is sixteen times, or about double the proportions in ordinary shipbuilding, but one fourth of its length at each end projects beyond the deck and bulwarks. This peculiarity in construction gives very fine lines to the hull, whilst it leaves the deck and bulwarks so far back from the ends of the hull, that it is expected it will not be liable to ship seas. The skin plates are of the best quality iron and steel from the works of Messrs. John Brown and Co., and the Low Moor Iron Company; at the bottom and sides they are of iron, and on the top of toughened steel. Their thickness at the bottom is ⅝ths of an inch midships, and diminishing gradually to ⅜ths at the ends; the bottom is strengthened by a plate of iron on the outside of the skin plates, one inch thick and 33in. broad midships, tapering to a point towards the ends; the thickness of the top plates of steel is $\frac{5}{16}$ths of an inch midships, tapering to one quarter of an inch at the ends. The top is strengthened for 130ft. midships, by four longitudinal ribs of steel, which support the deck, making the top of the vessel equally as strong to resist thrust and tension, as the bottom. There are bulkheads and iron lower decks, which divide the vessel into eighteen watertight compartments. These, together with iron ribs, running around the vessel 4in. deep and 3ft. apart in the engine and boiler-room, and 7in. deep and 6ft. apart at other parts, take the place of the numerous ribs in other vessels. The skin plates being all arched in every direction, gives them great stiffness and makes it unnecessary to place ribs so close together, as in other vessels. The workmanship of the hull appears to be equal to the best locomotive boiler work; every single skin and joint plate and angle of iron and steel, composing the hull, has been shaped and had its rivet holes laid off by a mathematical calculation, and when put in place, the rivet holes all perfectly matched. The arch in every direction in the skin plates has been put in them by machinery.

There are two screw propellers, one at each end of the vessel, connected and turned together by a steel shaft; they will be 22ft. in diameter, and but half immersed in the water; the points, 16ft. in length, which project beyond the propellers, are portions of the hub and revolve with the propeller. The engines and boilers occupy 48ft. 6in. in length, midship, leaving commodious accommodation for saloons, state rooms, &c. The boilers, four in number, have each a rectangular fire box, surmounted by two vertical cylinders, which contain vertical tubes; the centre portions of the boilers, 22in. in diameter are left free from tubes, for facility of

getting into the boiler for cleaning and for getting better circulation. They are made of the best Low Moor Iron and sufficiently strong to bear constantly a pressure of 150lbs. to the square inch. There will be a fan in the boiler room, for augmenting the draft of the chimneys, and for ventilating the ship. The engines are surface-condensing, and will work at a high grade of expansion; there are three cylinders, which are steam jacketted. Above each cylinder a shaft is placed, upon which are two cranks, working down by the sides of the cylinder; the piston-rods pass the shaft and are connected to a cross-head above, upon which there are two rods, connected with the cranks. The three engines are connected together by a system of return cranks and a peculiar coupling, which prevents cross strains from the power transmitted from one engine to the other, and from the shafts of the different engines getting out of line; this description of engine allows the longest possible stroke to be had in a given space below the shaft. With natural draft for the fires, the power developed by the engines will be about as great in proportion to the square of the cube root of displacement, as the Cunard Company's paddle-wheel steamer *Scotia*, and there is room and displacement in the vessel for coals, sufficient to work the engines to this power for twelve days. When artificial draft will be employed for the fires, the power developed by the engines will be a little more in proportion to the square of the cube root of displacemeet, than the paddle-wheel mail steamers plying between Holyhead and Kingston, which are the highest powered and fastest ocean steamers that have yet been produced, they having run at a speed of 18 knots, or 21 statute miles per hour. We believe it is the expectation of the constructors to demonstrate that sea going vessels can be built upon their plan, which will have advantages in comfort, safety, speed, and economy, beyond any vessels that have yet been constructed.

We understand that Messrs. Winans have made a great number of experiments during the past seven years, with vessels of the spindle form, having their cross-sections in every part a perfect circle. In the year 1858, they made a set of experiments at Baltimore for ascertaining the friction of water on surfaces of different smoothness and at different speeds, and the relative resistance at different speeds of vessels of the same displacement, but with proportions of length to breadth, varying from four times up to thirty-two times, also the advantages of vessels of the spindle form, as compared with those of the ordinary description, as far as this could be ascertained by models of comparatively large size. In the year 1859 they built an experimental vessel of the spindle form, at Baltimore, with a single large propeller, placed midship. A short description of this vessel was at the time published in our columns.* Many experiments were made during the years 1860 and 1861, to test, in rough and smooth water, the sea-going and other qualities of this vessel. Messrs. Winans also built a second experimental vessel of the same form, with a submerged propeller at the stern, as in ordinary screw vessels, at St. Petersburg, Russia, in 1861, with which they made experiments both in smooth and rough water. The fact that a third vessel of the same form and principle, and of considerable dimensions and power, is now being constructed by them with two propellers, one at either end of the vessel, would indicate that their experiments with this form of vessel have proved satisfactory. The hull and machinery are now in an advanced state, and it is, we understand, expected that the yacht will be completed for use, by the middle of July next.

* Vide Artizan. Vol. 1858.



PROFESSOR ZEUNER'S TABLE OF THE PROPERTIES OF SATURATED STEAM.

The table we publish in our present number is a reproduction of that computed by Herr G. Zeuner, Professor of Applied Mechanics at the Federal Polytechnic Institute, of Zurich; we have added the columns 3, 5, 7, 15, and 17, in order to render the results more intelligible to our readers. The table is based on the mechanical theory of heat; Professor Zeuner states that he calculated the values given in the table by means of Thomas's Calculating Machine which proved very useful for this purpose.

The first column contains the pressure of steam in atmospheres, advancing by tenths of an atmosphere from 1 to 7, and by fourths from 7 to 14 atmospheres. In the second and third columns the same pressures are given in millimetres, and inches of mercury, as denoted by the barometer; while in the fourth and fifth columns, the same pressures are given respectively in kilograms and pounds per square metre and square inch. The sixth and seventh columns contain the centigradial and Fahrenheit degrees of heat for the various pressures of saturated steam, as deduced by interpolation from Regnault's data. Thus, the temperature of saturated steam at a pressure of five atmospheres is 152·22° C = 306·00 F.

To render columns 8, 9, and 10 intelligible the following deductions will be required. Supposing a certain space, for example, a cylinder of a section F to contain 1 kilogram of water at 0° (C), and, by heating it, saturated steam of a pressure p (kilos per square metre) and a given temperature to be intended to be produced. The cylinder piston rests on the surface of the water, and at a distance s_1 from the bottom; the volume of water contained in the cylinder will be, therefore,

$$F\, s_1 = w.$$

The piston also is supposed, at the beginning of the trial, to be loaded by a weight p per unit of area, and the pressure on the piston to be equal to that of the steam to be generated. In heating the water, its temperature will at first rise from 0° to t° (C), before steam is generated; then, at a temperature t, the expansive force of the steam will be sufficient to overcome the pressure p, and thus to move the piston.*

Let q be the quantity of heat necessary to raise the temperature of the water from 0° to t°. This quantity, according to Regnault's formula, will be

$$q = t + {\cdot}00002\, t^2 + .0000003\, t^3 \quad \ldots\ldots\ldots\ldots \quad (1)$$

If the heating process continues, steam will be generated that will reach the pressure p, and the piston will be pushed forward, until the whole of the water has been transformed into steam; supposing, at this moment, the distance of the piston from the bottom of the cylinder to be $= s_2$, the volume of the unit of weight of steam generated at a pressure p will be

$$F\, s_2 = v.$$

* In all these calculations the kilogram, the metre, and the degrees of the centigradial thermometer are adopted as units. The columns 3, 5, 7, 15, and 17, were inserted in our table merely for the convenience of those not acquainted with the decimal (metrical) weights, measures, &c.

During the evaporation, the pressure and temperature remain constant, the heat r that must be supplied during the operation is called *latent heat* or, according to Clausius, *heat of evaporation.* The total quantity of heat that must be supplied to water at 0°, in order to obtain under a constant pressure, the unit of weight of steam of a pressure p, is

$$Q = q + r \quad \ldots\ldots \quad (2)$$

for which value of Q (generally called the *aggregate heat of steam*) M. Regnault gives the formula—

$$Q = 606{\cdot}5 + {\cdot}305\,t \quad \ldots\ldots \quad (2a)$$

Now the steam has, during its generation, performed a certain amount of work, having acted with a pressure F p on the piston, which has travelled through a space $s_2 - s_1$; the work done will be, therefore,

$$F\,p\,(s_2 - s_1)$$

or else, as we called—

$$F\,s_2 = v \text{ and } F\,s_1 = w$$

it will be—

$$p\,(v - w)$$

The value $v - w$ represents the difference between the unit of weight (1 kilo) of steam at a pressure p, and the corresponding unit of weight of water, which latter may be considered constant at the various temperatures and = 1 cubic decimetre. To simplify the calculation, we shall call—

$$v - w = u \quad \ldots\ldots \quad (3)$$

so that the labour performed by the unit of steam during its formation will be $= p\,u$.

Now, according to the mechanical theory of heat, every production of work requires the transformation of a certain quantity of heat, and it has been ascertained by experiments that one unit of heat or a *calorie* can be produced by a quantity of work = to 424 kilogrammetres; or reciprocately, $\frac{1}{424} = A$ will be the quantity of heat corresponding to one unit of work, or one kilogrammetre. A is called the calorific equivalent of one unit of work. In multiplying by A the quantity of work $p\,u$ required for generating steam under a constant pressure p, the co-efficient

$$A\,p\,u$$

will represent the quantity of heat that is absorbed during this formation. From the quantity of heat Q required to transform at a constant pressure p one unit of weight of water of 0° into steam of a pressure p, will therefore be abstracted the quantity of heat $A\,p\,u$ during the process of generation of steam, *i.e.*, another quantity of heat J will be obtained through the equation—

$$J = Q - A\,p\,u \quad \ldots\ldots \quad (4)$$

This is called *the heat contained in the steam*, or *the heat of the steam.* J also indicates how many calories (units of heat) will be found in one unit of weight of saturated steam of a pressure p, in addition to those contained in one unit of weight of water at a temperature 0°.

The latent heat or *heat of evaporation* r, on the contrary, represents, according to our notations, the quantity of heat that must be supplied to the water that has already been brought to the temperature of the steam to be generated, in order to convert it into steam, supposing, however, the generation of steam to take place under a constant pressure. In deducting, therefore, the quantity $A\,p\,u$ of heat converted into work from the value r, the difference ρ will denote by what amount of heat the unit of weight of steam of a temperature t will exceed the unit of weight of water of the same temperature.

The co-efficient,

$$\rho = r - A\,p\,u \quad \ldots\ldots \quad (5)$$

is called the *internal latent heat.*

The two quantities J and ρ are very important co-efficients. They are both entirely independent of the way in which the steam is generated; whereas, in introducing in calculations the total heat Q, and the heat of evaporation r, it must be borne in mind that with them the generation of the steam is supposed to take place under a constant pressure.

The quantity of heat converted into labour during the process of generation of steam under a constant pressure may be denoted with very great precision by the empirical formula—

$$A\,p\,u = B \log \frac{T}{n} \quad \ldots\ldots \quad (6)$$

in which B and n are two constants, for which in calculation, 30,456 for B, and 100 for r have to be substituted. T is what is called the *absolute temperature, i.e.,*

$$T = 273 + t.$$

The column (8) has been calculated by means of formula (6).

The values of Q and r, in formulæ (4) and (5) being known from Regnault's experiments, the co-efficients J and ρ may be deduced therefrom. In availing himself of these experiments, Prof. Zeuner found for the heat of evaporation, the formula

$$J = 573{\cdot}34 + {\cdot}2342\,t \quad \ldots\ldots \quad (7)$$

for which he calculated the values contained in column (9).

He found, moreover, for the temperatures that are met with in steam engines, that the internal latent heat is represented by the formula

$$\rho = 575{\cdot}03 - {\cdot}7882\,t \quad \ldots\ldots \quad (8)$$

from which the tenth column has been calculated.

Example. Supposing the steam to act at a pressure of 5 atmospheres the heat converted into labour is

$$A\,p\,u = 44{\cdot}083 \text{ calories,}$$

for a quantity of labour corresponding to

$$44{\cdot}083 \times 424 = 18{,}691{\cdot}19 \text{ kilogrammetres,}$$

the heat of steam being

$$J = 608{\cdot}99 \text{ calories,}$$

and the internal latent heat

$$\rho = 455{\cdot}05.$$

From equation (4) is found, as the total heat of this steam,

$$Q = J + A\,p\,u = 653{\cdot}07^{*}$$

and the heat of evaporation

$$r = \rho + A\,p\,u = 499{\cdot}13.^{\dagger}$$

The equation

$$J - \rho = q \quad \ldots\ldots \quad (9)$$

which is obtained by deducting formula (5) from (6), will be found to agree with equation (2). From equations (7) and (8) is deduced, for the heat that can bring water from $o°$ to $t°$

$$q = -1{\cdot}69 + 1{\cdot}0224\,t \quad \ldots\ldots \quad (10)$$

which is a convenient co-efficient for the temperatures steam engines generally work at.

It may be concluded therefrom that the specific heat of water at average temperatures will be

$$c = 1{\cdot}0224 \quad \ldots\ldots \quad (11)$$

The foregoing explanations are sufficient to render the next columns of the table intelligible. Column 11 contains the values of u, which are obtained by dividing the co-efficients $A\,p\,u$ of column 8 by $A\,p$. Column 12 contains the values of the co-efficient $\frac{\rho}{u}$, deducted from columns 10 and 11. These latter co-efficients will prove to be of very great importance in practice.

The value of equation (3) differs very little from v, the specific volume of water u being so small, as compared to w, that, in most cases, it may be neglected with safety. ρ denotes the internal latent heat of the unit of weight, and, consequently, $\frac{\rho}{u}$ may be considered as *the internal latent heat of the unit of volume* (*i.e.*, 1 cubic metre) of steam.

The column 13 shows that the differences in the values of $\frac{\rho}{u}$ decrease very slowly with the pressure; this internal latent heat of the unit of weight is therefore proportional to the tension of steam.

Finally, we may deduct from formula (3) the specific volumes of the steam, or the volume of 1 kilogramme of steam at different pressures, and

$$v = u + w \quad \ldots\ldots \quad (12)$$

for the specific weight of steam we have seen that we may take w = ·001; in this manner the value of v may be obtained. These values are contained in column 14 in cubic metres for kilogrammes, and in column 15 in cubic feet for pounds avoirdupois. The density γ, or weight of 1 cubic metre of steam at various temperatures, may be reciprocally obtained by the formula

$$\gamma = \frac{1}{v} \quad \ldots\ldots \quad (13)$$

These values are contained in a like manner in columns 16 and 17, respectively, for French and English measures and weight.‡

* Mr. Regnault's formula (2 bis.) gives 652·93.
† According to Regnault's formula r = 499·20.
‡ 1 kilogramme = 2·205lbs. avoirdupois; 1 metre = 100 centimetres = 3·2809ft.; 1 square metre = 10000 square centimetres = 10·76 square feet; 1 cubic metre = 35·32 cubic feet.

TABLE OF THE PROPERTIES OF SATURATED STEAM.

Pressure in					Temperature.		Quantity of steam converted into work during the production of steam.	Heat of steam.	Latent internal heat.	Values of u.	Values of ρ/u	Differences.	Volume.		Density.	
Atmospheres.	Millimetres of Mercury.	Inches of Mercury.	Kilogrammes per square metre. p	Lbs. avoirdupois per square inch.	Centigradial. t	Fahrenheit.	Apu	J	ρ				Volume of one kilogramme of steam in cubic metres. v	Corresponding volume of 1lb. avoirdupois in cubic feet.	Weight of 1 cubic metre in kilogrammes. γ	Corresponding weight of 1 cubic foot in lbs.
0·1	76	3	1033·4	1·470	46·21	115·18	35·349	584·16	538·61	14·5034	37·14		14·5044	184·563	0·069	·0054
0·2	152	6	2066·8	2·939	60·45	140·81	36·679	587·50	527·38	7·5246	70·09	32·95	7·5256	95·760	0·133	·0105
0·3	228	9	3100·2	4·409	69·49	157·02	37·493	589·61	520·26	5·1278	101·46	31·37	5·1288	65·262	0·195	·0153
0·4	304	12	4133·6	5·879	76·25	169·25	38·089	591·20	514·93	3·9069	131·80	30·34	3·9079	49·726	0·256	·0201
0·5	380	15	5167·0	7·349	81·71	179·26	38·562	592·48	510·63	3·1644	161·37	29·57	3·1654	40·262	0·316	·0248
0·6	456	18	6200·4	8·818	86·32	187·38	38·954	593·56	506·99	2·6638	190·33	28·96	2·6648	33·909	0·375	·0295
0·7	532	21	7233·8	10·288	90·32	196·36	39·292	594·49	503·84	2·3030	218·77	28·44	2·3040	29·318	0·434	·0341
0·8	608	24	8267·2	11·758	93·88	200·98	39·589	595·33	501·03	2·0304	246·77	28·00	2·0314	25·849	0·492	·0387
0·9	684	27	9500·6	13·227	97·08	206·74	39·853	596·08	498·51	1·8168	274·38	27·61	1·8178	23·131	0·550	·0432
1·0	760	30	10334·0	14·697	100·00	212·00	40·092	596·76	496·21	1·6450	301·05	27·27	1·6460	20·950	0·617	·0477
1·1	836	33	11367·4	16·167	102·68	216·82	40·310	597·39	494·10	1·5036	328·62	26·97	1·5046	19·145	0·665	·0523
1·2	912	36	12400·8	17·636	105·17	221·31	40·512	597·97	492·13	1·3851	355·29	26·67	1·3861	17·638	0·722	·0567
1·3	988	39	13434·2	19·106	107·50	225·35	40·699	598·52	490·30	1·2845	381·70	26·41	1·2855	16·358	0·778	·0611
1·4	1064	42	14467·6	20·576	109·68	229·42	40·873	599·03	488·58	1·1978	407·88	26·18	1·1988	15·254	0·834	·0655
1·5	1140	45	15501·0	22·046	111·74	233·13	41·036	599·51	486·96	1·1225	433·82	25·94	1·1235	14·296	0·890	·0699
1·6	1216	48	16534·4	23·515	113·69	236·72	41·190	599·97	485·42	1·0563	459·56	25·74	1·0573	13·454	0·946	·0743
1·7	1292	51	17567·8	24·985	115·54	240·97	41·336	600·40	483·96	0·9976	485·11	25·55	0·9986	12·707	1·001	·0787
1·8	1368	54	18601·2	26·455	117·30	244·14	41·473	600·81	482·57	0·9453	510·47	25·36	0·9463	12·041	1·057	·0831
1·9	1444	57	19634·6	27·924	118·99	246·18	41·605	601·21	481·24	0·8984	535·64	25·17	0·8994	11·444	1·112	·0874
2·0	1520	60	20668·0	29·394	120·60	249·08	41·730	601·58	479·97	0·8561	560·67	25·03	0·8571	10·906	1·167	·0917
2·1	1596	63	21701·4	30·864	122·15	251·87	41·849	601·95	478·75	0·8176	585·52	24·85	0·8186	10·416	1·222	·0960
2·2	1672	66	22734·8	32·333	123·64	254·55	41·964	602·30	477·58	0·7826	610·23	24·71	0·7836	9·971	1·276	·1003
2·3	1748	69	23768·2	33·803	125·07	257·13	42·073	602·63	476·45	0·7505	634·80	24·57	0·7515	9·563	1·331	·1046
2·4	1824	72	24801·6	35·273	126·46	259·63	42·180	602·96	475·35	0·7211	659·21	24·41	0·7221	9·188	1·385	·1088
2·5	1900	75	25835·0	36·743	127·80	262·04	42·282	603·27	474·30	0·6939	683·50	24·29	0·6949	8·842	1·439	·1131
2·6	1976	78	26868·4	38·212	129·10	264·38	42·380	603·57	473·27	0·6688	707·66	24·16	0·6698	8·523	1·493	·1173
2·7	2052	81	27901·8	39·682	130·35	266·63	42·475	603·87	472·29	0·6454	731·71	24·05	0·6464	8·225	1·547	·1216
2·8	2128	84	28935·2	41·151	131·57	268·83	42·567	604·15	471·33	0·6237	755·63	23·92	0·6247	7·949	1·601	·1258
2·9	2204	87	29968·6	42·620	132·76	270·97	42·656	604·43	470·39	0·6035	779·42	23·79	0·6045	7·692	1·654	·1300
3·0	2280	90	31002·0	44·091	133·91	273·04	42·742	604·70	469·48	0·5846	803·12	23·70	0·5856	7·452	1·708	·1342
3·1	2356	93	32035·4	45·561	135·03	275·05	42·826	604·96	468·60	0·5668	826·72	23·60	0·5678	7·225	1·761	·1384
3·2	2432	96	33068·8	47·130	136·12	277·02	42·907	605·22	467·74	0·5501	850·20	23·48	0·5511	7·012	1·814	·1426
3·3	2508	99	34102·2	48·500	137·19	278·94	42·987	605·47	466·90	0·5345	873·57	23·37	0·5355	6·814	1·867	·1467
3·4	2584	102	35135·6	49·970	138·23	280·81	43·064	605·71	466·08	0·5197	896·86	23·29	0·5207	6·626	1·920	·1509
3·5	2660	105	36169·0	51·439	139·24	282·63	43·139	605·95	465·27	0·5057	920·05	23·19	0·5067	6·448	1·973	·1551
3·6	2736	108	37202·4	52·909	140·23	284·41	43·212	606·18	464·50	0·4925	943·16	23·11	0·4935	6·280	2·026	·1592
3·7	2812	111	38235·8	54·379	141·21	286·18	43·284	606·41	463·73	0·4800	966·14	22·98	0·4810	6·121	2·079	·1634
3·8	2888	114	39269·2	55·849	142·15	287·87	43·353	606·63	462·99	0·4681	989·09	22·95	0·4691	5·969	2·132	·1675
3·9	2964	117	40302·6	57·318	143·08	289·54	43·421	606·85	462·25	0·4568	1011·92	22·83	0·4578	5·833	2·184	·1716
4·0	3040	120	41336·0	58·788	144·00	291·20	43·488	607·06	461·53	0·4461	1034·63	22·71	0·4471	5·689	2·237	·1758
4·1	3116	123	42369·4	60·258	144·89	292·80	43·553	607·27	460·83	0·4358	1057·31	22·68	0·4368	5·558	2·289	·1799
4·2	3192	126	43402·8	61·727	145·76	294·37	43·617	607·48	460·14	0·4261	1079·91	22·60	0·4271	5·435	2·341	·1840
4·3	3268	129	44436·2	63·197	146·61	295·90	43·678	607·68	459·47	0·4168	1102·45	22·54	0·4178	5·316	2·393	·1881
4·4	3344	132	45469·6	64·667	147·46	297·43	43·740	607·87	458·80	0·4079	1124·87	22·42	0·4089	5·203	2·446	·1922
4·5	3420	135	46503·0	66·137	148·29	298·92	43·800	608·07	458·15	0·3993	1147·21	22·34	0·4003	5·094	2·498	·1963
4·6	3496	138	47536·4	67·606	149·10	300·38	43·859	608·26	457·51	0·3912	1169·51	22·30	0·3922	4·991	2·550	·2004
4·7	3572	141	48569·8	69·076	149·90	301·82	43·916	608·45	456·88	0·3834	1191·71	22·20	0·3844	4·891	2·602	·2045
4·8	3648	144	49603·2	70·546	150·69	303·32	43·973	608·63	456·26	0·3759	1213·85	22·14	0·3769	4·796	2·653	·2085
4·9	3724	147	50636·6	72·015	151·46	304·63	44·028	608·81	455·65	0·3687	1235·93	22·08	0·3697	4·701	2·705	·2126
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

TABLE OF THE PROPERTIES OF SATURATED STEAM.

Pressure in					Temperature.								Volume.		Density.	
Atmospheres.	Millimetres of Mercury.	Inches of Mercury.	Kilogrammes per square metre. p	Lbs. avoirdupois per square inch.	Centigradial.	Fahrenheit.	Quantity of steam converted into work during the production of steam. Apu	Heat of steam. J	Latent internal heat. ρ	Values of u.	Values of $\frac{\rho}{u}$	Differences.	Volume of one kilogramme of steam in cubic feet. v	Corresponding volume of 1lb. avoirdupois in cubic feet.	Weight of 1 cubic metre in kilogrammes. γ	Corresponding weight of 1 cubic foot in lbs.
5·0	3800	150	51670·0	73·485	152·22	306·00	44·083	608·99	455·05	0·3617	1257·94		0·3627	4·615	2·757	·2167
5·1	3876	153	52703·4	74·955	152·97	307·35	44·137	609·16	454·46	0·3551	1279·87	21·93	0·3561	4·531	2·807	·2206
5·2	3952	156	53736·8	76·424	153·70	308·66	44·189	609·34	453·88	0·3487	1301·78	21·91	0·3497	4·450	2·859	·2247
5·3	4028	159	54770·2	77·894	154·43	309·97	44·241	609·51	453·31	0·3425	1323·57	21·79	0·3435	4·371	2·911	·2288
5·4	4104	162	55803·6	79·364	155·14	310·25	44·291	609·67	452·75	0·3365	1345·34	21·77	0·9375	4·295	2·963	·2329
5·5	4180	165	56837·0	80·833	155·85	312·53	44·342	609·84	452·19	0·3308	1367·00	21·66	0·3318	4·222	3·014	·2369
5·6	4256	168	57870·4	82·301	156·54	313·77	44·391	610·00	451·64	0·3252	1388·66	21·66	0·3262	4·151	3·066	·2410
5·7	4332	171	58903·8	83·773	157·22	315·00	44·439	610·16	451·11	0·3199	1410·24	21·58	0·3209	4·083	3·116	·2449
5·8	4408	174	59937·2	85·241	157·90	316·22	44·487	610·32	450·57	0·3147	1431·73	21·49	0·3157	4·017	3·168	·2490
5·9	4484	177	60970·6	86·710	158·56	317·40	44·534	610·47	450·05	9·3097	1453·20	21·47	0·3107	3·954	3·219	·2530
6·0	4560	180	62004·0	88·182	159·22	318·60	44·580	610·63	449·53	0·3048	1474·59	21·39	0·3058	3·891	3·270	·2570
6·1	4636	183	63037·4	89·652	159·87	319·77	44·626	610·78	449·02	0·3002	1495·93	21·34	0·3012	3·833	3·320	·2609
6·2	4712	186	64070·8	91·121	160·50	320·90	44·670	610·93	448·52	0·2956	1517·26	21·33	0·2966	3·774	3·371	·2649
6·3	4788	189	65104·2	92·591	161·14	322·05	44·715	611·08	448·02	0·2912	1538·44	21·18	0·2922	3·718	3·422	·2689
6·4	4864	192	66137·6	94·261	161·76	323·17	44·759	611·22	447·53	0·2869	1559·65	21·21	0·2879	3·663	3·472	·2729
6·5	4940	195	67171·0	95·731	162·37	324·27	44·801	611·37	447·05	0·2828	1580·81	21·16	0·2838	3·611	3·523	·2769
6·6	5016	198	68204·4	97·000	162·98	325·36	44·844	611·51	446·57	0·2788	1601·87	21·06	0·2798	3·560	3·574	·2809
6·7	5092	201	69237·8	98·470	163·58	326·54	44·886	611·65	446·10	0·2749	1622·90	21·03	0·2759	3·511	3·624	·2848
6·8	5168	204	70271·2	99·940	164·18	327·70	44·928	611·79	445·62	0·2711	1643·87	20·97	0·2721	3·462	3·674	·2887
6·9	5244	207	71304·6	101·409	164·76	328·57	44·968	611·93	445·17	0·2674	1664·82	20·95	0·2684	3·415	3·725	·2927
7·00	5320	210	72338·0	102·879	165·34	329·61	45·008	612·06	444·71	0·2638	1685·70	20·88	0·2648	3·369	3·776	·2967
7·25	5510	217·5	74921·5	106·553	166·77	332·19	45·108	612·40	443·58	0·2553	1737·66	51·96	0·2563	3·261	3·902	·3066
7·50	5700	225	77505·0	110·228	168·15	334·67	45·203	612·72	442·49	0·2473	1789·38	51·72	0·2483	2·159	4·027	·3165
7·75	5890	232·5	80088·5	113·902	169·50	337·10	45·296	613·04	441·43	0·2398	1840·79	51·41	0·2408	3·064	4·152	·3263
8·00	6080	240	82672·0	117·576	170·81	339·46	45·386	613·34	440·40	0·2328	1891·96	51·17	0·2338	2·975	4·277	·3361
8·25	6270	247·5	85255·5	121·350	172·10	341·78	45·475	613·64	439·38	0·2261	1942·80	50·84	0·2271	2·890	4·403	·3460
8·50	6460	255	87839·0	124·924	173·35	344·03	45·560	613·94	438·39	0·2199	1993·44	50·64	0·2209	2·811	4·527	·3558
8·75	6650	262·5	90422·5	128·595	174·57	346·23	45·643	614·22	437·43	0·2140	2043·85	50·41	0·2150	2·736	4·651	·3655
9·00	6840	270	93006·0	132·273	175·77	348·39	45·725	614·50	436·49	0·2084	2093·95	50·10	0·2094	2·665	4·775	·3753
9·25	7030	277·5	95589·5	135·947	176·98	350·49	45·804	614·78	435·56	0·2032	2143·85	49·90	0·2042	2·598	4·897	·3848
9·50	7220	285	98173·0	139·622	178·08	352·54	45·881	615·05	434·67	0·1981	2193·56	49·71	0·1991	2·534	5·023	·3947
9·75	7410	292·5	100756·5	143·260	179·21	354·53	45·957	615·31	433·78	0·1934	2242·94	49·38	0·1944	2·474	5·144	·4043
10·00	7600	300	103340·0	146·970	180·31	356·56	46·031	615·57	432·91	0·1889	2292·16	49·22	0·1899	2·416	5·266	·4138
10·25	7790	307·5	105923·5	150·644	181·38	358·48	46·103	615·82	432·07	0·1845	2341·25	49·09	0·1855	2·360	5·391	·4237
10·50	7980	315	108507·0	154·319	182·44	360·39	46·174	616·07	431·23	0·1804	2390·03	48·78	0·1814	2·308	5·513	·4333
10·75	8170	322·5	111090·5	157·993	183·48	362·26	46·243	616·42	430·41	0·1765	2438·62	48·59	0·1775	2·259	5·634	·4428
11·00	8360	330	113674·0	161·667	184·50	364·10	46·311	616·55	429·61	0·1727	2487·01	48·39	0·1737	2·210	5·757	·4524
11·25	8550	337·5	116257·5	165·341	185·51	365·92	46·379	616·79	428·81	0·1691	2535·11	48·10	0·1701	2·165	5·879	·4620
11·50	8740	345	118841·0	169·016	186·49	367·68	46·444	617·01	428·04	0·1657	2583·18	48·07	0·1667	2·121	5·998	·4714
11·75	8930	352·5	121424·5	172·690	187·46	369·43	46·508	617·34	427·27	0·1624	2631·00	47·82	0·1634	2·079	6.120	·4810
12·00	9120	360	124008·0	176·364	188·41	371·14	46·571	617·46	426·52	0·1592	2678·66	47·66	0·1602	2·039	6·242	·4905
12·25	9310	367·5	126591·5	180·038	189·35	372·83	46·633	617·68	425·78	0·1562	2726·08	47·42	0·1572	2·000	6·361	·4999
12·50	9500	375	129175·0	183·713	190·27	374·47	46·693	617·90	425·06	0·1533	2773·38	47·30	0·1543	1·963	6·481	·5093
12·75	9690	382·5	131758·5	187·387	191·18	376·12	46·753	618·11	424·34	0·1504	2820·47	47·09	0·1514	1·927	6·605	·5191
13·00	9880	390	134342·0	191·061	192·08	377·74	46·812	618·32	423·63	0·1477	2867·32	46·85	0·1487	1·892	6·725	·5285
13·25	10070	397·5	136925·5	194·735	192·96	379·33	46·869	618·53	422·94	0·1451	2914·11	46·79	0·1461	1·859	6·845	·5379
13·50	10260	405	139509·0	198·409	193·83	380·89	46·926	618·73	422·25	0·1426	2960·69	46·58	0·1436	1·827	6·964	·5473
13·75	10450	412·5	142092·5	202·084	194·69	382·32	46·982	618·94	421·59	0·1402	3007·22	46·53	0·1412	1·797	6·982	·5566
14·00	10640	420	144676·0	205·758	195·53	383·95	47·037	619·14	420·91	0·1378	3053·39	46·17	0·1388	1·766	9·205	·5662
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

(To be continued).

INSTITUTION OF CIVIL ENGINEERS.

ON THE MEANS OF UTILIZING THE PRODUCTS OF THE DISTILLATION OF COAL, SO AS TO REDUCE THE PRICE OF COKE; WITH DESCRIPTIONS OF THE OVENS AND OF THE BEST PROCESSES IN USE IN GREAT BRITAIN AND ON THE CONTINENT, IN THE MANUFACTURE OF COKE.

By M. Pernolet (of Paris).

The Author believed that this question had been practically solved, by the employment of existing ovens, to which certain inexpensive additions were made, and which, while still giving to the coke all the solidity, density, and lustre that distinguished good coke made in the ordinary way, enabled every product of the distillation of coal to be turned into account. This was effected, mainly, by keeping the coal from all contact with the air during its distillation, by performing that process very slowly, and by collecting and making use of the volatile products. The whole arrangement had been sanctioned by many years' experience, both in Belgium and France, where it was actively and profitably pursued at ten different establishments, with more than four hundred ovens, of the largest dimensions, capable of receiving from 5 to 7 tons of coal at each charge.

In converting an old oven into one of the improved form, the floor was taken up and raised about a foot, so as to allow of its being heated from below, by means of a fire-grate and flues. A new opening was made in the roof, in which was fixed a pipe, intended to receive the volatile products, and to conduct them to their destination. The ordinary door and the other opening at the top were so arranged that they could be kept hermetically closed. A chimney was also added to the masonry of the old ovens, and this was an essential part of the system, as it secured the circulation of the products of distillation. It had been ascertained that this chimney should be 50ft. high, and not less than 3½ft. square, inside dimensions, for a group of sixteen contiguous ovens; and that the sectional area of the main flue, connecting the different ovens with the chimney, should be three-fourths that of the chimney. In order to try whether the distillation was finished in any one oven, a valve was closed in the outlet pipe; when if the charring was incomplete, the gas still given off would cause cracks in the loam, with which the joints of the door were closely luted, and thus the necessity for continuing the process was demonstrated. The valve was then simply re-opened, so as to allow the gas again to pass off by the pipe. If, on the other hand, when the valve was closed, no gas escaped at the joints, the charring was known to be finished, and the coke was fit to be drawn. During this operation the valve was closed, to prevent the mixture of the external air with the gases circulating in the outlet pipe, and the cast-iron cover of the opening at the top was kept shut, to avoid the risk of igniting the coke by the draught of air which would be created if it was open. The oven was arranged for charging from the top, by means of waggons running upon rails, and in this way 5 tons of coal could be introduced in fifteen or twenty minutes, a rapidity which was most desirable for preserving the heat of the oven. When the charge was being withdrawn and replaced, the gas from the other ovens was allowed to pass continually into the fire-place, so that the floor was kept hot, and the gas accordingly began to show itself, above the opening at the top, only a few minutes after the closing of the door. This opening was then hermetically sealed, and the valve in the outlet pipe being raised, the communication was re-established between the interior of the oven and the great common flue. The products of the distillation were drawn off by the draught of the chimney, together with the condensation of the liquid, and the cooling of the gaseous products. After circulating in the great general flue, the products penetrated into the condensing apparatus, where they deposited most of the tar and ammoniacal liquor, and returned to the ovens by the small general flue, whence the gas, purified and dried, passed to each fire.

The time occupied in charring varied with the nature of the coal, and the density desired for the coke, and with the arrangement of the oven. At St. Etienne it took upwards of seventy-two hours, with rich coals, while at Terteron the time occupied was only twenty-four hours, with the rather poor but flaring coals of Commentry.

As to the cost, it was stated that the expense of altering each oven at St. Etienne was about £20, and that as the value of the additional yield from each oven ought to be about £60 per annum, this outlay should be repaid by four months work.

It was asserted that the supplementary products due to these arrangements were, a larger yield of coke, and all the tar, the ammoniacal liquors, and the gas, which would be obtained from the same coals, if distilled in the retorts of a gas manufactory. Thus, in the great coke works at St. Etienne, the yield had been advanced from 58·8 to 69·3 per cent., and in the "Fonderies et Forges d'Alais" from 54·6 to 69·5 per cent. Generally speaking, with rich, or partially rich coals, the increase in the yield of coke was from 10 to 15 per cent. As to the tar, the proportion collected depended on the nature of the coal, and on the care taken, both in the distillation of the coal, and in the condensation of its volatile products. It had averaged 2·53 per cent. at the Forges d'Alais, 3 per cent. at Elonges, 3·25 per cent. at St. Etienne, and had reached as high as 5 per cent. from the ovens of the Paris Gas Light Company, where only very bituminous coals were employed; but it was thought that there might be reckoned 3 per cent. of tar from the bulk of the coal distilled. The proportion of ammoniacal liquors depended also on the quantity of moisture contained in the coal; but it might be stated at a weight of not less than 10lbs. of sulphate of ammonia, and sometimes it was as much as 13lbs. per ton of coal distilled. At the ovens of the Paris Gas Light Company from 10,000 to 11,500 cubic feet of purified gas were generally obtained from a ton of coal, which yielded from 69 to 70 per cent. of coke, fit for delivery to the railway companies.

INSTITUTION OF NAVAL ARCHITECTS.

ON THE CONSTRUCTION AND PROPULSION OF TWIN-SCREW VESSELS.

By Capt. T. E. Symonds, R.N., Assoc.

Captain Symonds commenced by urging that a war ship, of whatever denomination, was of comparatively little use unless possessing the highest attainable power of manœuvring, under all circumstances. This, he contended, was not to be obtained by the single screw; for, although acting fairly under favourable conditions, there was nothing approaching certainty under the ever-varying circumstances in which ships are liable to be placed; whereas, if fitted with twin-screws, a ship might be turned in any direction, regardless of wind or current, whether stationary or otherwise, with almost the same certainty and precision as a railway turn-table; and, in the event of the rudder being lost or injured, the steering power of the two screws was sufficient to guide the ship in any direction—such power being derived from the source of motion, it acted instantly on the course of the ship, and not gradually, as in the case of the helm. A twin-screw ship might thus be said to possess a duplex power of steering as well as propulsion. He then went on to observe that there were many collateral advantages attached to the system, quoting many practical examples in support of his views, both as regarded speed, economy of fuel, and sea-going qualities, &c., adduced in the voyages made by the several ocean steamers on this principle built by the Messrs. Dudgeon, in some of which the peculiar attributes of the system had a most remarkable illustration, in hair-breadth escapes from Federal cruisers, &c. Capt. Symonds then proceeded to review the history of "twin-screws," remarking that, although introduced many years previous, the great advantages to be derived from the system did not appear to be recognised till the application of separate and independent engines, in 1852. When the late Mr. Richard Roberts, C.E., patented that system in this country, as applied to large ships—in connection with two keels and two rudders—and, about the same time, he believed, some experiments had been made by Mr. George Rennie in a small boat, for light draught purposes, the success of which induced him, some years after, to build many gun-boats on that principle for the Indian and foreign Governments, but that of late years the system had fallen into disuse. Captain Symonds gave credit to the Messrs. Dudgeon for adopting this system for ocean service, against the opinions and prejudices of most shipbuilders, and stated that the result obtained by these vessels had induced their owners to build others, which was, after all, the best practical test of their excellence. He believed that it would be found, ere long, that the application of the principle to large ships would develop its advantages even more than in the class of vessels already built, and that it would be of the greatest importance in its bearing on a reduction of draught and consequent increase of beam in armour-plated, or any weight-carrying ships—it was an opinion he had long entertained and contended for in conjunction with his late lamented friend, Mr. Roberts; and the results attained in the *Far East*, a ship of 1,300 tons, with two auxiliary lifting screws and 150 horse-power, went far to confirm him in it, the accounts of this vessel being of a highly satisfactory character. He considered the division of the engines of much advantage, the parts being smaller, lighter, more manageable, and capable of greater perfection in the manufacture than the present engines; they might also, when necessary and convenient, be distributed over a larger surface; or, if required, they might be arranged in a space not exceeding the present limit of the engine-room. He dwells much on the advantage accruing from the use of one screw, one set of boilers, and engine in making a passage, working a lee screw under canvas, or in "laying to" in a gale, the ship steering perfectly under such circumstances, and losing only one-third her speed, all of which had been proved in practice. Referring to the use of the system in merchant ships, he pointed out that ships of great draught would thus not only have their screws working to the greatest advantage when loaded, *viz., deeply immersed*—but that when light they would still be as deeply immersed as the single screw when at load draught. Hence the ship would thus be always in trim, and not necessitate her sea-going qualities and speed being sacrificed by trimming her by the stern, and thus elevating the bow in an unsightly and dangerous manner. He considered that this system applied as an auxiliary power with lifting screws would be very serviceable for transports. He was aware that some objections might be urged against this system; but what system was free from objections? He thought that it had been happily remarked by Mr. Reed last year that in shipbuilding, and more especially war-ship building, there was a series of compromises. He believed that fewer would be required in the twin-screw system than any other. If shipbuilders still considered great length necessary to great speed, they must have something more than the present rudder to steer with. Mechanical appliances might fail, especially if rigid, and no manual power could be brought to bear on the rudder-head that would supply their place so effectively to move such an area of rudder as had been mentioned during the late discussion. He was of opinion that the fact of such cumbrous and costly arrangements being necessary for steering single-screw ships of large size was in itself a sufficient argument against persisting in that system. Captain Symonds then referred to diagrams, showing the method of fitting twin-screws with two keels and two rudders, and one keel with ordinary rudder to the *Enterprise*, by which means the propelling and steering agents in such a vessel would be entirely removed from danger (especially in the former) without extending the after-body and clothing it with heavy armour for the protection of screw and rudder, which he contended did not, after all, protect them, but added very materially to the weight at the after extremity and interfered with the delivery of the water. He considered that in either system of fitting the twin-screws, the ship would be relieved of considerable weight aft, the displacement might be increased, and the ship altogether would be a better weight-carrier and livelier sea boat. The screw, as it now exists, is immersed about 2ft. 6in., and is 1ft. off the ground, the rudder projecting beyond the stern, whereas the twin-screws would be immersed 5ft. 6in., being 3ft. clear of

the ground, and the rudders in both system of twin-screws being many feet within the line of the ship. In speaking of the turning qualities of the twin-screw ship for working broadside guns, he exhibited a model and diagrams of a light-draught frigate, showing an arrangement recommended by him in May, 1863, for firing either two or three guns right a-head from the upper deck, capable of being depressed to strike a boat within twenty yards of the ship; and two guns from the main deck, at an angle of twenty degrees with the keel, as bow and stern chasers. By the facilities afforded in iron construction this latter arrangement he shows is easily effected. He thus arms his broadside ship at all points, making her capable of doing her work as a seagoing vessel, fighting her guns under any circumstances by the aid of the twin-screws, without altering her normal construction. He believed that such a ship having upper deck guns —her propelling and steering agents deeply immersed so as to ensure their continuous and regular action and defend them from accident—would be more formidable than cupola or turret-ships which require more complicated and comparatively more exposed machinery in working their guns. He exhibited a plan for converting our present line-of-battle ships into harbour-defence ships, for which he claimed many advantages over the *Royal Sovereign*, not the least being on the score of expense and time occupied in fitting. He believed that he could fit three such ships in the time and for the cost expended on the *Royal Sovereign*, that should be, to all intents and purposes, as good or better for the service she is capable of being employed upon. He also drew attention to his patent method of lifting screws through the quarter in a diagram, showing the *Warrior* fitted with twin-screws made to lift, and pointed out the advantages that this system possessed over the single screw, by retaining the central part of the after body perfect, instead of cutting it away for the screw aperture, which not only weakened the ship but interfered with the steerage; whereas, in the twin-screw system the apertures for lifting the smaller screws were in the quarter, not being much larger than ports, and not weakening the structure; when these were lifted and closed, the ship was, to all intents and purposes, a perfect sailing ship. Capt. Symonds observed that the arguments brought against this system were principally of a theoretical character; and that it was remarkable that those who had questioned the value of the system had never witnessed an experiment, although frequently urged to do so; and that without an exception, those who spoke in its favour, though in some instances doubting its advantages at first, had become converts by witnessing its practical working. He by no means complained of objections being made, but he thought dogmatic assertions as to the impossibility of results that had been witnessed by competent judges (many of whom were present) should not be permitted undue weight. Adverting to an opinion which had been expressed by the chief constructor of the navy, on a recent occasion, as to a "single screw, of a given diameter, being more effective as a propeller than two screws together of greater diameter"—taking the conditions, he gives, viz., "a ship with 15ft. screw being faster than another with two screws of 10ft." Supposing the revolutions and pitch to be the same, the effect of the single screw might be greater if properly immersed, but as the smaller screws can be driven at a greater velocity, with the same power to make up for the difference in diameter, they will produce an effect in excess of a single one. The engines and screws being lighter, there will be less friction, and a higher speed of piston being obtained without risk or vibration, and, as is well known, with an economy of fuel unapproachable at low speeds. The two small screws having the manifest advantage of being under several feet head of water, their whole diameter is more effective, and their action constant and uniform; whereas the single screw in the centre of the run works in the junction of two currents, the upper blade being near the surface, and often out of water. Captain Symonds observed that the proportions given were arbitrary; two 12ft. screws might be used, or even larger, if necessary, and thus additional power might be applied to a ship of moderate draft, which no single screw could develope in such a vessel. He contended that the turning power of a single screw, under whatever "judicious development" Mr. Reed might place it, would never approach that attained by the twin-screws, and he felt confident that no practical seaman, who had witnessed the performance of a twin-screw vessel would dispute it. He believed that this system was in its infancy, and that many points would come out in experiments in vessels more suitable to the development of the principle than those already built; *and that the larger the ship was, the more the advantage of the system would be felt.* He considered the success attained by Messrs. Dudgeon in the class of vessels they have applied it to was very encouraging, and one which had already borne fruits. He cordially concurred with those who advocated experiments on an extensive scale, it was what he had vainly endeavoured to obtain for a series of years, feeling confident that so long as they were conducted properly, they would not fail to elicit the most interesting and important facts; and when applied in a proper manner to vessels capable of developing the system, would fully bear out everything he had claimed for it. Captain Symonds next called attention to the fact that he had persistently urged the adoption of the method of fitting twin-screws with two keels and two rudders, as originally invented by Mr. Richard Roberts, and that it was a source of satisfaction to him to observe that, although not adopting that system in its integrity, the Government had decided on building some of the new twin-screw gunboats on that principle—adding, that in all the models and plans he had had the honour of submitting, whether to the Government, to this, or any other Institution, the principle lately distinguished as the U form of bow-section, and characterised by some as a beautiful and novel feature in naval architecture, was invariably introduced in those models. Quoting from a Paper which he read at the Royal United Service Institution in March, 1862, wherein he thus describes it after recommending the adoption of an elliptical mid-section:—"The flat elliptical floor is continued to the fore foot, thus the fore body is made self-supporting (the heavy part of the sharp floor as in other ships being dispensed with) it is consequently more buoyant, and combined with the long floor, will reduce the tendency to pitch, and will 'lift' in going against a head sea!" Captain Symonds concluded by remarking that, if present opinions, with regard to wooden frames proved correct, he felt satisfied that the twin screws fitted to double keels would prove the best method, for absence of vibration in the former (a wooden ship's greatest enemy), and the strength imparted to the whole fabric by the latter, and the central part of the after body not being cut away for the screw aperture, as in a single screw-ship, would relieve the constructor of many difficulties he would inevitably have to contend with in the single screw system. He also felt very confident that in any twin-screw ship, but especially in the one described, he would undertake to produce a ship between the same perpendiculars, at any given draught with an equal motive power, that should have greater displacement, steam faster on a less consumption of fuel, roll less, and be to all intents and purposes a cheaper ship, a better sea-boat, and a more efficient ship of war than any single-screw steamer afloat.

SOCIETY OF ARTS.

ON THE TESTING OF CHAIN CABLES.

By Mr. Frederick Arthur Paget, C.E.

It is, no doubt, generally known that a select committee of the House of Commons is now considering a bill for the compulsory testing of the chain cables and anchors of merchant vessels. This may be said to lend a passing interest to a question which, however, needs no chance help in calling for our attention.

Without entering into lengthy statistics, or calculating the number of times that the total length of all the chain cables in actual use would measure round the world, we should be scarcely mistaken in the supposition that in different parts of the globe there are, at this very moment, many hundreds of valuable lives, and thousands' worth of property, in each case dependent upon a single link of the hundred fathoms that make up the length of an average chain cable; for there are situations in which a ship is often placed wherein the cable must be literally the thread of life of the vessel. To the seamen of the present age, the iron cable, though of comparatively recent introduction, is a common everyday thing. Those of the last generation could remember the time when only hempen cables were in use. The naval men of that time were thus led to look upon chain cables as the most precious gift ever made in modern times to the mariner —to repeat the words of the late distinguished Captain Basil Hall.

Now, although we have been testing chain cables according to certain Admiralty regulations established ever since 1831, although the naval administrations of France, Russia, and other countries have exactly copied these regulations, and although Lloyd's have adopted the Admiralty test—which is somewhat more than the so-called "merchant" test—it is a remarkable fact that a difference of opinion with regard to almost every point connected with the use and testing of chain cables still exists amongst engineers and other men of science. This differing of doctors is very strikingly shown by the Blue Book report from the 1860 Select Committee of the House of Commons on anchors and chain cables for the merchant service. One witness states that 50 per cent. of the loss of life by shipwrecks are due to bad cables and anchors; another that very few wrecks occur through bad anchors and cables. One objects to the Navy proof as being too high; another as too low. One witness considers that the cross-stay does not add to the strength of the link; another that the cross-stay is a great improvement. In the same way, directly contrary opinions were elicited from different witnesses with regard to the duration of cables under wear, their re-testing, re-annealing, and other points. A similar want of agreement on these matters exists in France; and it would thus appear that several interesting engineering questions, connected with the strength, the testing, and the re-testing of chain cables, offer a fair field for practical examination.

According to the Admiralty regulations, an iron chain cable has to consist of eight lengths, each $12\frac{1}{2}$ fathoms long, including one swivel in the middle of every other length, and one joining shackle to each length. Neglecting the swivels and shackles, each link may be described as a cylinder, the axis of which is wound into a shape approximating to that of an ellipse. The width over all, or across the minor axis, is made $3\frac{1}{2}$ diameters (full) of the cylindrical bar. The length over all, or across the major axis of the supposed ellipse, is six diameters The cast-iron stud across the minor axis is made 0·6 of a diameter in the centre, and one diameter at each of its ends. This stud not merely acts as a cross-stay, but also preserves the freedom of the joints, or what may be termed the mechanical flexibility of the cable. The weights are of course exactly fixed in the Government tenders. The weight of, for instance, a one-inch link stay-pin must not exceed $3\frac{1}{2}$ ounces, and the weight, fixed by contract, of a hundred fathoms of cable, in 8 lengths, including 4 swivels and 8 joining shackles, must not be exceeded by more than 1-20th part. The experience of many centuries has determined the sizes of hempen cables for ships of a given tonnage; and, the sizes of the hempen cable being thus given, it is easy to substitute a chain cable of the required strength. Mr. J. R. Napier has proposed a formula, according to which one-eighth of the cube root of load displacement would give the diameter of the chain cable usually employed by steamers of the present form. In the Admiralty comparative table, showing the weights and strengths of stud chains and hempen cables, there is a noticeable relation between the girths of the hempen cables and the diameters of the iron employed in chain cables. The number of inches of the circumferences of the hempen cables pretty nearly expresses in lines, or twelfths of an inch, the diameters of the iron cables of equal breaking strength. The material of the links is No. 3 rolled bar, and very good cable bolts generally cost from £1 to £2 above common bars. According to experiments by Telford, Hodgkinson, Mr. Edwin Clark, and Mr. Kirkaldy, and also according to numerous experiments at Woolwich, we may safely take the ultimate breaking strength of cable bars at 24 tons to the square inch, and their limit of elasticity, under a tensile stress, at 12 tons to the square inch. These bars would stand a pressure up to deformation of 18 tons to the square

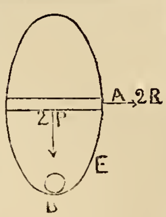
nch, and 15 tons pressure at the elastic limit. The ultimate tensile strength of a round bar of this iron would thus be nearly 19 tons. According to the evidence of the leading man of the test house at Woolwich, in 1860, this ultimate statical breaking strength is only occasionally exceeded, when it rises up to about 20 tons for a one-inch round bar, or 25·33 tons per square inch. He also stated that a great number of experiments made at Woolwich showed the greatest breaking strength of one-inch chain cables to be only 28·31 tons. Contrary to the popular assumption that a stud link should be, in the direction of its length, twice the strength of a single bar, this result would show a loss in strength of 28·75 per cent. According to the comparative table published by the Admiralty, the one-inch bolts should stand 21 tons 8cwts., and the stud link therefrom, 34 tons 5cwts. It also appears to have been assumed (for it could scarcely have been proved by experiment) that the strength of the cable bolt, and of the link therefrom, both increase almost exactly in the ratio of the diameter of the bars. Thus, the breaking of two-inch bolts is given as 21 tons 8cwts., × 4 = 85 tons 12cwts., to which two tons are added; the strength of chain therefrom as 34 tons 5cwt. × 4 = 137 tons, and the proof as 18 × 4 = 72 tons. It is, however, well known to engineers that, as a rule, a two inch bar is not practically as strong as a one-inch bar of even exactly the same make and by the same maker, and that the strength becomes less and less as the bulk still further increases. The proportions adopted by the Admiralty, appear, however, to compensate for this loss, and there is very nearly the same average ratio of breaking strength to diameter in all chains, from five-eighths to two inches. But, even according to the Admiralty tables, there is a remarkable amount of strength lost in forming the iron into the link. The loss of strength was well known to Sir Samuel Brown, the introducer of chain cables. He thus patented, in 1817, the straight link used in suspension bridges, and first applied it to the Brighton chain pier.

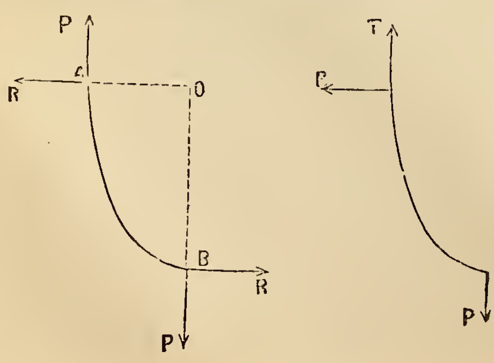
There are several reasons why a portion of the strength of the bar should be lost in forming it into a cable link. The principal causes are:—1st. The mechanical shape of the link; 2nd. The crushing stress undergone by the insides of the crowns; 3rd. The deterioration in strength of the iron through its being bent; 4th. The loss of the strength at the welds.

In the first place, each link is, when the cable is pulled in the direction of its length, subjected to a tranverse strain at each of its ends or crowns, and is somewhat in the condition of a curved beam loaded in the middle. An originally curved beam is, with regard to bending stress, in the same condition, at any cross-section at right angles to its neutral surface, as a straight beam under the same moment of flexure. The moment of flexure of one end of a common unstayed link can be expressed in inch-pounds by multiplying half the span, or half the distance in the clear, by the load in pounds. In the case of the stayed link, however, the moment of thrust of the cross-stay has to be subtracted from the moment of the bending force. The mechanically weakest part of any link is thus at the crowns.* Now, it is a curious fact, that all the writers on the strength of materials, from Professor Peter Barlow, Mr. Edwin Clark, and others, down to General Morin, in 1862, give the strength of a link furnished with a cross-stay to be equal to that of the iron of which the link is made.

In a mathematical sense, the contact between the links is only at a point, because it is a case of two cylinders touching each other at right angles. Under a load, this point will spread out to a surface of an area given by the amount of the load and by the compressibility of the iron. This surface will then probably increase, in the case of a one-inch cable under a load of nine tons, up to more than half a square inch. And thus at the ends, the softer and more ductile the iron, the sooner will it be worn away in practice, and the progressive deteriration caused by this crushing action will also be furthered by the friction.

* For the sake of simplicity, let us suppose the cross-sectional area of the link as infinitely small compared with its major and minor axes, and suppose it provided with a cross-stay. Let 2P denote the whole pulling force; 2R the thrust of the stay; T the tension at A. For the equilibrium of the quarter link, B E A, we have the forces P, R, T, and the forces at B arising from the left-hand quarter at A. From symmetry this must be horizontal (in the figure), and we must therefore have:—Force at B = R, and T = P. The moment of the bending force at B is therefore not P × oA, but only P × oA — R × oB. On the other hand, when the link is on the point of breaking by opening at B, the tension will not be equal to the ultimate tension throughout the section at B, but only at the lowest point, and when this has given way a little, the tension, previously supported, is thrown on a fibre higher up, which then gives way, and so on. Hence the strength is less than if the tension were throughout the section as great as possible.





An attempt to account for the reduction in strength through the bending of the cylindrical bar has next to be made. Wrought iron is known to be a crystallized body, belonging to the cubic system. Now Mr. Mallet, in his important work "On the Physical Conditions involved in the Construction of Artillery," has shown that these crystals are not grouped amorphously (or without distinct arrangement); but that they always take a certain determinate position. He has developed the law that "iron, whether in the state of cast or of wrought iron, has the principal axes of its integrant crystals arranged in the lines of least pressure within the mass" while exposed to pressure and heat in progress of manufacture. The principal axes of the crystals in a rolled bar would thus be set in a direction coincident with the length of the bar, and, from the property of malleability possessed by these metallic crystals, they would further take, under the pressure of the rolls, or the impact of the forging hammer, the longitudinal extension known as the "fibre" of wrought iron. Mr. Edwin Clark found that bars cut longitudinally and transversely to the fibre of the same plate of an excellent quality of iron, gave with the fibre a strength of from 19·66 to 20·2, and across the fibre a strength only of 16·7 tons to 16·93 tons. The ultimate elongation also of the plate in the line of the fibre was double as great as transverse to it. A great number of experiments by Mr. Kirkaldy gave somewhat similar results.* He found that the difference averaged from 21·7 to 2·1 per cent., the mean difference in the whole being 9·8 per cent. in favour of the direction of the fibre. The respective ultimate elongations were also in almost the same rates as those found by Mr. Clark. It would thus appear from these experiments, and from a consideration of Mr. Mallet's law, that both the elastic range and breaking strength of wrought iron of any given quality are, to a certain amount, dependent on the direction of the crystalline axes in relation to the strain; and further, the elasticity would be at a maximum in the direction of the principal axes of the crystals, or "line of fibre." The crystals in a bar subjected in the direction of its longitudinal axis to a tensile or a compressive stress, would thus be in the most favourable condition with regard to its ultimate breaking strength and its elastic limit. But when, say, a red-hot bar is being bent, the principle axes of its crystals would, according to the law of cross-bending strains, arrange themselves above and below a neutral axis in the direction of least pressure within the mass; the neutral axis would probably pass through the centre of gravity of the bar, the fibres on the concave side would elongate in the ratio of their distances from the neutral axis. The hot iron itself would be, at any rate on the concave side, under a somewhat similar influence as when passing through the last pair of rolls, but the directions of least pressure, instead of being coincident with the length of the bar, would be at right angles to tangents to the neutral axis. Much of this is, of course, founded on several unproved assumptions, but it is at any rate evident that the molecular arrangement of the iron at the crown of the link is in the worst condition for resisting the tensile and compressive strains on each side of a neutral axis that make up the compound action of a transverse stress. The late Professor Daniell's process for unmasking the fracture and the arrangement of the fibre of wrought iron, by immersing the piece in dilute hydrochloric acid, would doubtless reveal a distortion of the crystals round a neutral axis.

It would thus appear that the crown of the link is its weakest part. This is, however, very far from being practically the case. Each link has of course to be welded up, and the weld is in one of the sides, with a long scarf, in order to get a large welding surface. When we recollect that there are, in round numbers, 1,800 links, and, consequently, 1,800 welds, in a one-inch hundred-fathom chain cable, and also that the efficiency of the cable depends on each individual link, the paramount importance of the welds is obvious. In nine cases out of ten, while in use and while being tested, the links are found to give way at the sides. Breakages would, *cæteris paribus*, have a tendency to occur at the welds with good iron but bad workmanship, and in the iron, and not in the weld, if good workmanship but bad iron were employed. The uncertainty of welds is in any case well known to practical men. Mr. Kirkaldy has made some eighteen experiments on the relative strengths of welded joints in wrought iron. Some of these welds were made by a chain-maker. Only six of the specimens broke solid away from the weld, and in every case there was a loss of ultimate breaking strength averaging from 2·6 to 43 per cent., the mean being nearly 20 per cent. As with almost everything else belonging to the subject of chain cables, one of the witnesses before the Committee of 1860, raised the question whether the position at one of the sides was the best for the weld. Mr. Smale, of Woolwich, proposed to weld the link at the crown, as there would thus be more room for the smith, and any bad weld would be less hidden by the cross-stay. The crown is, however, as we have seen, *ab initio*, the weakest part of the link. Besides, if a weld at the side gave way, the other half might catch and save the cable; at the same time, however, a sudden giving way at the weld would cause an instantaneous distortion and probable rupture of the opposite side, as the sudden "run" of the cable would act with an impulsive force. In fact, when iron cables were first introduced, the welds were made at the crown, but the plan had to be given up. It is clear enough that there are, *cæteris paribus*, three weak places in a link where any effects of stress would first show themselves—the two crowns and the weld at the side.

We thus see what a powerful element of uncertainty is brought by the uncertainties of workmanship into such an apparently simple thing as a chain cable. When, however, we remember that the very best wrought iron of commerce is, to use the words of the well-known metallurgist Saint-Claire Deville, but a metallic sponge, like platinum, the pores of which have been simply closed up by pressure or percussion; that, in one word, ordinary wrought iron has never, as wrought iron, been fused, it will be seen that the uncertainties qualifying the material itself are still greater. Mr. Mallet thus found that while the original hammered slab of a very large forged mass had a breaking strength of 24 tons to the square inch, it fell progressively to 17 and 16 tons at

* *Vide* THE ARTIZAN Vols. for 1860 and 1863.

the different places of the mass, down to even as low as 6½ tons in some parts. Unless this iron had been burnt, its tenacity could doubtless have been restored, and if drawn into wire, its breaking weight might have been increased to perhaps ninety tons to the square inch—at least before annealing. An average of 188 experiments, made by Mr. Kirkaldy on rolled bars, gave a maximum breaking strength of 30¾ tons, and a minimum of nearly 20 tons to the square inch. These influences of the manufacture merely on the quality of wrought iron are almost independent of the chemical constitution of any individual bar. For instance, until it be proved to the contrary, there are many reasons for the general belief that the cold shortness of wrought iron is due to the presence of silicon and carbon; and its hot shortness to that of sulphur. A fractional per centage of copper also makes wrought iron hot-short. In truth, there are probably no two bars or parts of a bar of an exactly similar chemical composition, or in an exactly similar state of molecular aggregation, and therefore of an exactly similar breaking strength or elastic limit. Even these are only a few of the elements of uncertainty in structural materials. But when we further take into account the varied strains of extension, compression, distortion, twisting, and bending to which mechanical structures are more or less subject; that the work done by a gradually-applied load is doubled if this load be applied suddenly; that the impulsive strain of a moving load is generally more or less intensified by vibration; and that the varied shapes and arrangements intended to receive these strains must be often as much fixed by financial as by scientific considerations, then the reason that the best engineering practice makes the ultimate strength of a wrought iron structure from four to six times the working load must be even popularly evident. But these factors of safety are not sufficient. The structure must be tested as searchingly, and as far as is consistent with safety—as far as is possible without injuring the material and its relation to the structure. In our case this limit is, in the main, given by the limit of elasticity of wrought iron under extension, as this limit is less for wrought iron than that of compression. It is also self-evident that the mode of testing adopted ought to approximate as nearly as practicable with the kind of stress the object is intended to undergo in practice. It is also evident that if circumstances allow us to exceed this limit, if, in fact, we can push the test as far as the breaking strength of a portion, or of an individual piece of the object, we shall obtain the safest amount of information about its qualities. In this way guns and plates are both tested to destruction. In order to test the probable performance of rails under a moving load, a certain number, taken from a lot, are broken by a falling weight, the distance between the supports and the height of fall being fixed by contract. The French test their railway carriage axles in a somewhat similar manner. There is no test so good as a blow for detecting a false weld. In Sweden they do not confine themselves to the usual gunpowder proof for gun barrels, but two or three sharp taps with a hammer are given along the breech, which have an immediate effect on a bad weld. All the whipple chains for the carriages of the Royal Swedish Artillery are tested by letting the loose end fall from a height double the length of the chain, after being attached to a weight. The anchors for the French Imperial Marine are tested by being dropped from a determined height for each size. The axles for the carriages of the Messageries Générales and the Imperial Artillery are tested by the impact of a falling weight. All the swords and sabres for the army are tested by striking the blades on a block of wood. When we advance from details to considerable structures, we are, of course, obliged to very carefully confine ourselves within the limits of elasticity. After loading a railway bridge with the greatest passive, or perhaps impulsive load that would ever come upon it in practice, the deflection, and the permanent set, if any, are both carefully noted. As a boiler is subjected in practice to a complex train of mechanical and chemical forces that are always striving to break their bonds, its ultimate strength is made from six to eight times the working stress, and it ought to be periodically tested to half its working pressure. Its extension under this pressure is sometimes—and should always be—measured by the volume of water that is pumped in by pressure after the boiler has been filled; while the permanent set is determined by the difference between the volume pressed out by the contraction of the boiler when the pressure is withdrawn, and the volume of the water that remains in the boiler after the test—allowance being of course made for any slight leakages and sweating at the joints. In first-class locomotive works the deflection and permanent set of the steel springs are always tested in an apparatus for the purpose. It may here be remarked that, although the designs of all the successful wrought iron structures ever built have been based on the assumption of a limit of elasticity, nevertheless the relation of the permanent set of wrought iron to its ultimate resistance under a given load, is still a subject of some discussion. We have, on the one hand, the testimony of Professor Eaton Hodgkinson, who says that "the maxim of loading bodies within the elastic limit has no foundation in nature;" and, on the other hand, some appear to believe that iron is even improved by breaking it under, at least, a tensile stress. Mr. Hodgkinson found that a rod, 10ft. long and of one square inch section, took a permanent set of 0·0005 of an inch under a static load of less than 1¼ tons. Mr. Edwin Clark obtained very similar results. Such a microscopic set, however, could be referred to the elongation caused by the heat generated by the internal friction of the particles, or to the probable fact that these bars were also new; and it is conceivable that they might have taken a slight permanent set, just as new ropes take a permanent set, without injury, when the strain is first applied. There are, indeed, very few forms of wrought iron in which its internal particles are not, *ab initio*, subject to some mutual strain. At any rate, these elongations were very slight, and increased uniformly up to tensions varying from about 10 to 15 or 16 tons on the square inch. Beyond these strains the bars elongated in an irregular manner, until they at last broke. At the same time, as Dr. Rankine remarks, the demonstration by Mr. E. Hodgkinson that a set is produced by a strain much less than what would injure the specimen, renders the determination of the proof-strength a matter of some obscurity; but Dr. Rankine points out that the best test now known is the not producing an increasing set by the repeated application of a load. Some years ago, Mr. Loyd, of Woolwich, made certain experiments which have been cited as proving that a breaking strain does not injure iron, even when this strain is four times repeated; or rather, that after breaking a bar into, say, two pieces, the two pieces are thereby made stronger. In, for instance, experiment 2, the 1⅝ bar marked C was found to break with 33¾ tons, with a stretch of 9¼in. in 54in.; a piece of this bar then broke at 35¼ tons, with a stretch of only a quarter of an inch in 36in.; another piece of the bar, 24in. long, was broken at 37 tons, with a stretch of one inch; and at the fourth and last breakage was found to give way at 38¾ tons, but without any stretch at all. Results of a similarly delusive kind, obtained by Professor Walter Johnson, were communicated by him to the United States Government in 1845. He found that by heating a bar to a temperature of 400° Fahrenheit (or the temperature of steam at about 250lbs. pressure), and stretching it permanently for about 6½ per cent. of its length, it, on being broken, gave an ultimate breaking strength about 20 per cent. higher than a portion of the bar that had not been heated and stretched. He therefore supposed that, to use his own words, "the value for useful purposes, added to a bar of iron by thermo-tension, when the increase of both length and tenacity is taken into account, may be safely set down at 26 per cent. of its original value. It sometimes exceeds 30 per cent. On a single cable, 100 fathoms long, made of iron 2¼in. in diameter, weighing about 15 tons, and attached to a line-of-battle ship, the gain, in true commercial value, would not probably fall short of 600 dollars." A machine was made by the American Government, in order that the Professor might apply his principle of "thermo-tension" directly to chain cables, but as nothing else ever appears to have been heard about the matter, we have thus, as usual, lost another of the lessons always taught by scientific accounts of scientific failures. The pitch chains of the old engines of the *Great Britain* are stated, by Mr. Guppy, to have been stretched one-eighth of an inch while at a low red heat. This was, no doubt, an excellent method for testing the soundness of the work. Captain Blakely also stretches the hoops that are shrunk on his guns. This is done on a maundrel, and while the rings are at a red heat; but it is stated that only one-sixth of the breaking strain of the cold metal is applied. The action of the maundrel also probably re-arranges the crystalline aggregation which had been disturbed by bending the ring from a straight slab. The red heat of iron is only visible in daylight at a temperature of 1,077 degrees Fahr., and the heat used by Professor Johnson was only from 400 to 500 degrees. But the "gain of length"—the permanent set, in fact—of from 5 to nearly 7 per cent., sufficiently shows that the bars had either been broken or were close upon fracture. His results, in fact, merely anticipated those of Mr. Loyd. The breaking strength of his bars was doubtless increased, but with a proportionate diminution, perhaps, indeed, a complete destruction, of their elasticity. They were rendered harder, for what is the hardness of a body but the resistance of its particles to any temporary re-adjustment? The longitudinal elongation was accompanied by a lateral contraction of the cross-sectional area that would reach its culminating point at the part where fracture happened to take place. Exactly the same argument, founded on similar experiments on cables themselves, was used before the 1860 Committee, in order to prove that cables are not injured by a breaking strain; but a mere statement of the progressive diminution of the elongations would have detected the fallacy.

The apparent increase of ultimate strength through successive breakages, thermo-tension, and much of the high static breaking strength acquired through cold rolling, and cold hammering, even through wire-drawing previous to annealing, are referable to an increase of hardness, to an increase of the difficulty of the gliding to and fro, to a resistance to the inter-mobility of the particles, to, in one word, a diminution of elasticity. If the numerous experiments that have now been made on iron do prove anything, it is that the breaking strength does not indicate the quality—the breaking strength must be taken conjointly with the elongation. The true measure of the mechanical value of wrought iron is simply the sum of the products of the successive loads and the increments of elongation—in other words, the resilience of the bar or the deflection of the beam, or the work performed in producing the stretch or deflection. We thus see the value of Poncelet's symbols T_e and T_r, advocated with such ability in England by Mr. Mallet. Upon the just balance of strength of fibre, or high breaking strength, and extensibility or ductility, depends the mechanical or structural value of iron.

The Navy test for chain cables is stated to be the result of a number of careful experiments by the late Sir Samuel Brown, and it was adopted by the Admiralty in 1831, when chain cables were fairly established in the royal service. The test adopted by the French Navy is almost exactly the same, and in Russia and the States it is exactly the same, as both those countries use our own measures and weights. Every chain cable is proved by a gradually-applied stress of 630lbs. for each circular one-eighth of an inch of the area of the bolt of which the cable is made, or 11·46 tons to the square inch on each side of the link.

Assuming that a link is subjected in practice to a tensile stress, and as the proof strength is generally fixed at double the working stress, this would correspond to nearly 5¾ tons on the square inch. There is thus a very close correspondence between the working stress assumed for chain cables and the Board of Trade limit of 5 tons to the square inch, imposed about 16 years ago, for both the tension and compression of the wrought iron of railway structures. The chain cable of a ship is also evidently subjected to impulsive forces. It is true that a ship, when struck by a sea, in most cases merely lifts the weight of her chain, the catenary curve of which thus acts as a kind of water-brake; but a very heavy sea must occasionally bring a sudden pull on the cable, and in shoal water the sudden strain must be almost solely taken up by the resilience of the cable, or rather by the deflection of the series of beams composing the cables. Much security is, however, afforded by the fact that a cable is generally only strained during a brief interval of time. But few cables can stand a sudden nip at the hawse pipe; and we thus see that lateral as well as longitudinal strength is occasionally required in a cable.

If two one-inch diameter cable bars of average quality, and, say, each ten feet long, be put into the hydraulic press generally used for testing cables, the following appearances will probably be observed:—If new, they will take a very slight set under a stress of about $1\frac{1}{4}$ ton to the square inch, but if this stress be gradually increased, and alternately eased off and put on several times, the set will not increase until the true elastic limit or proof strength of the material be exceeded. In our case this limit will probably be 12 tons to the square inch, which is thus higher by a little more than half-a-ton than the 11·46 tons navy test. At the Admiralty proof stress, each of the bars will have a probably total elongation of more than one-twentieth of an inch, and a permanent set of six-thousandths. Beyond this strain the set will very rapidly increase up to, perhaps, two inches, when the bars will break under a load of 24 tons to the square inch. But the phenomenon the most important in its consequences, consists in the contraction of cross sectional area undergone by the bar through the stretch. According to a theoretical investigation by Poisson, the relation of the contractions to the longitudinal elongation should be $\frac{1}{4}$; and Wertheim's experiments led him to believe that this relation should be $\frac{1}{3}$. Cauchy, Stokes, Maxwell, Rankine, and Lamé, have also mathematically investigated this question, and have arrived at results differing from those of Poisson, which were founded on a special atomic hypothesis. But the permanent sets that show themselves in ductile bodies, like annealed iron, under very slight loads, and the so-called internal frictions observed by Dr. William Thomson in metals under tension, would cause this relation of contraction to elongation to differ for every different state of a metal. To Kirchhoff is due a remarkably important investigation carried out in 1859, into the relation of the contraction to elongation under tension of hard steel wires—which may be said to approach the nearest to the ideal of a body possessing equal elasticity in different directions. His experiments, conducted with great delicacy, gave a relation of cross sectional contraction to elongation of 0·294. As we have seen, according to the Admiralty tables, a one-inch cable bolt ought to have an ultimate breaking strength of not less than 21 tons 8cwts. to the circular inch, or more than 27 tons to the square inch, and the link ought only to break at 34 tons. It is, however, very seldom that these strengths are obtained in practice. The ultimate elongations of the bars or the cables are not stated in the Admiralty tables. General Morin relates that the fine charcoal iron, made at Guérigny by the French Government, expressly for chain cables, sometimes elongates even more than one-fifth of its original length before breaking, and this amount is probably the utmost that it is possible to give to wrought iron bars.

When the cable itself is placed under the dead pull of the press, it is tested in three different ways. It is first strained up to 11·46 tons in the square inch sectional area across the double section of the link. While for about three or four minutes under this stress, the cable is subjected at different parts of its length to blows from a round-faced hammer. Different sized hammers are adopted in proportion to the size of the chain, and each fathom generally receives one blow. Each link is then carefully examined. Two or three links are broken up to detect, by its bluish tinge, if the iron has been at all burnt in the working, and also to make some estimate of the quality of the iron from the surface of the fracture, and the other appearances known to engineers. Some difference of opinion also exists, both in France and in England, as to the amount of security afforded by these tests, and whether the test of 11·46 tons on the square inch, and more especially the blows of the sledge, do or do not injure the cable. In 1855 it was attempted to introduce a compulsory government test in France for the chain cables of merchant vessels. A letter was addressed by M. David, an influential chain manufacturer at Havre, to the then imperial minister of public works, advocating a compulsory test, from motives of humanity to the ships' crews, and of public economy. A system of periodical re-testing, for every ten or twelve years that the cable had been at work, was also proposed. The attention of the then minister of the French marine was directed to the statements put forth, and Admiral Hamelin ordered an official investigation of the question. The results shown forth in the report would appear to have proved—at any rate to the satisfaction of the Imperial administration, that—1st. "The proof test of 17 kilogrammes, or even of 20 to 21 kilogrammes per square millimetre of section of the link, is not enough either to prove the good workmanship of the cables or the quality of the iron employed; 2nd. That a higher proof than 20 to 21 kilogrammes cannot be applied several times to cables without affecting their quality; 3rd. That the differences of useful effect between different presses often lead to errow with respect to the absolute value of the tension employed. . . . . The sum total of these results therefore shows, continues the minister, that, on the one hand, an increase of the proof test would not be of much effect in detecting bad material and workmanship, and on the other, that it would be dangerous to increase the test. The required security can only be obtained in a well-understood system of manufacture; and therefore, besides the test in the press, it is necessary to scrupulously choose the special quality of iron required; to accurately examine each individual link after the testing; to break up any questionable link; and to choose the most skilful and trustworthy operatives." In one word, the minister of the marine did not consider a government inspection of chain cables intended for the French merchant service as a practicable thing. It is to be remembered that all the chain cables for the Imperial navy are manufactured by the government.

Now there can be now doubt that the proof of 11·46 tons to the square inch is not enough of itself to test the quality of the workmanship, or, more definitely, the perfection of the welds. For this reason M. R. Bowman advocated before the 1860 Committee an increase of the test. It is clear that, as the sides are only tested up to little more than 11·46 tons, and as they would break at only, say, 24 tons to the square inch, less than one-half the sectional area of the iron would stand the test if applied only tensionally. As, however, through the cross-bending strain at the two ends, the link slightly tends to assume the shape of a lozenge, the weld is more severely tested than would at first appear. There is a certain difficulty in detecting a bad weld, upon the nature of which some practical light has been thrown by some experiments of Mr. Kirkaldy's on bars grooved round their circumferences. The matter had been previously investigated by the writers on elasticity, but Mr. Kirkaldy was the first to practically test the question. Bars grooved at any particular part down to a given diameter, gave a much higher ultimate breaking strength than bars of a diameter all through equal to that at the reduced part of the grooved bar. The wider parts on each side resisted the tendency to draw out, and a great apparent strength was thus obtained. The extent of this apparent gain was as much as $37\frac{1}{2}$ per cent. in some of the pieces, while the average gave 18·63 per cent. in favour of the grooved specimen. Here again we see the falsity of taking merely the breaking strength into account, for although the breaking strengths were thus increased, the elongation, and the contraction of area attendant on elongation, were proportionately less. It will thus be seen that a bad weld may be impaired by a strain in excess of the elastic limit due to the quality of the iron and the cross sectional area the solid metal, and that, although it is thus injured, it may not show signs of the injury. On the other hand, some security is given that a bad weld may be detected, from the fact that rolled iron is well known to be somewhat hardened by being hammered, and the welded-up side of the link would thus be less extensible than the opposite parallel side, and would thereby be rather more strained. It is evident, however, that though the test can scarcely be too high for the welds alone, the proof of more than fourteen tons to the square inch, proposed by M. David, would clearly be too high for the cable. M. David, indeed, stated that he tested his cables up to this amount, but it appears that the pressure he used was not accurately measured. Indeed, there is no doubt that very few cables would stand the ordinary proof if repeated sufficiently often, or if it were put on and eased off a succession of times, upon the plan shown by Dr. Rankine. As it is, the permanent set taken by cables is, on an average, from 4 to 6ft. in 90. But the best proof that this single application of the test for a short time does not injure good chain cables, is seen in the fact that it has been adopted all over the world for more than thirty years. We are, however, in a dilemma. To increase the proof would evidently be to injure the link, while the detection of a bad weld has, in any case, to encounter the difficulties just mentioned. These questions can only be met by a most careful inspection of each individual link. The quality of the iron can only be very closely tested by breaking up two or three links. The most searching tests, however, are the hammer blows given while the chain is under tension. Adapting a well-known and excellent illustration, this will be at once evident when we remember that a $1\frac{5}{8}$in. chain cable, made of glass, would give the same ultimate gradually-applied breaking strength as a one inch iron cable—but it would not be likely to stand the hammer-test. On the other hand, a cable of india-rubber, although not to be broken by the hammer, would at last be torn in two by the press. In fact, the hammer test approaches nearer than any other to the kind of work that will have to be done by the cable when at sea. Besides, the mere form of the chain renders it, *per se*, liable to continual shocks and jerks, and this must be encountered by a special quality of material, and that this material has really been used must be shown in the proving house.

Mr. Pope, the surveyor for Lloyd's at Liverpool, gave it as his opinion, before the Committee of 1860, that the navy test was too high, and had a tendency to injure the chain. This might be true for a chain of a bad material, but not for a chain made of iron with the high elastic limit that should alone be used for chain cables. He proposed to test a short piece to destruction, and then to test the entire chain up to half the Admiralty proof. Apart from the expense and destruction of material by this proceeding, there can be little doubt that half the usual test would not detect all the bad welds, and the distinctive peculiarity of a cable consists in the fact that a single bad weld is sufficient to cause the entire loss of the chain.

As we have seen that a cable consists substantially of a series of small curved beams, it would be only natural inquiry to ask why the sum total of their deflections, represented by the temporary elongation of the cable, and why the total permanent set should not be both registered, and be both taken into account when estimating the quality of a cable. There are, however, several influences that would greatly disturb an accurate deduction. It might, at first sight, be supposed that the defective welds would elongate in the inverse ratio of their areas of solid metal to that of the links. This, as we have seen, is not the case, and even if it were the case, the action would affect the deductions therefrom by variable and uncertain quantities. The links will also bed against each other to an amount given by the hardness of the iron. There can be no doubt that the extension must be taken into account with the breaking weight, when the quality of a bar has to be estimated. But even with bars this varies considerably, not merely in different qualities, but also, as was shown by Mr. Kirkaldy, in specimens of the very same brand. These results were also obtained under tensional stresses alone, and when we come to the combination of transverse, tensile, and directly compressive stresses to be found acting on a link, the varied ways in which these stresses act on varying qualities of iron, would scarcely render the deductions from the elongations and set sufficiently trustworthy. Again, to take an extreme case, if one half of, say 50 fathoms of cable were made of a very bad kind of iron, and the other half of very good quality, it would be difficulty to draw any right deduction from these appearances. As it is, however, the permanent set is generally registered.

There is probably no metal the strength of which is influenced in such a remarkable way by temperature as iron. As M. Baudrimont showed in 1850, the tenacity of iron is less at 100° C., than at 0° C., but at 200° it is greater than at 0°, and these results have been exactly confirmed by Dr. Fairbairn in some experiments on boiler plates, communicated in a paper to the British Association. At yet higher temperatures this tenacity is of course diminished; and Seguin has shown that iron, the tensile strength of which could be represented by 100 at 10° C., had this tenacity lowered to 90.5 at 370° C., and to 58·7 at 500° C. In the royal dockyards of Woolwich and Portsmouth the atmospheric temperature during the testing of each anchor or chain is carefully noted, although the proving houses themselves are kept at a mean temperature of 56° Fahr. by means of stoves, which also thus saves the water pipes from freezing.

This temperature of course falls a little during the winter and rises in summer, as the heat in the shade generally varies in England from about 76° to perhaps 34° Fahr. The action of frost on iron has not been completely investigated; and Dr. Percy recommends that some accurate experiments on the question be undertaken by the Institution of Civil Engineers. The daily observation of practical men has, however, as in so many other cases, preceded the deeper investigations of science. All workmen know that their tools, such as picks and chipping hammers, which have to undergo percussion in frosty weather, are then more liable to get broken. All chains are well known to be more subject to snap under the same circumstances. There is always a notorious increase of accidents through breakages, both in the permanent way and rolling stock, of railways during frosty weather. It is stated that during the severe winter of 1860–61, 498 rails were broken on the Chemin de Fer de l'Est, from the 11th December to the 31st January inclusive. No less than 258 were broken from the 21st to the 25th of January, during which period the thermometer descended to—7·8°, and even to—16° centigrade. General Morin relates that during the northern campaigns of the first empire the artillery veterans used to believe that wrought iron was subject to freezing, and after the long winter bivouacs they never began their day's march without striking the gun-carriage axles in the direction of their length, and the vibration thus produced was said to "thaw" the iron. An intense cold is also said to have enabled the French garrison of Hamburg to disable the cast-iron siege guns, by knocking off the trunnions before evacuating the place. Mr. Lennox stated, in evidence before the 1860 Committee, his belief that a cable would stand a test in warm weather that it might not in cold. The crews of the fishing vessels on the coast of Nova Scotia find that the cold renders their cables so brittle that a length of hempen cable is used for the portion out of the water, while the anchor end is kept from the vicissitudes of the atmosphere by the usual average temperature of the sea. A few experiments made by Mr. Kirkaldy showed that the breaking strength of a bar is slightly reduced by freezing when a gradual breaking load was applied, but that this difference between a frozen and an unfrozen bolt is much more increased by a suddenly applied load, being 3 per cent. less when frozen. The usual way adopted by French engineers to test rails is, as we have seen, to prove a percentage of the lot by means of a falling weight. Some tests were carried out a few years ago by M. Couche, on a number of rails, of very good quality, from the Anzin works. The monkey weighed 300 kilogrammes, and the distance between the supports was 1m. 10. When the thermometer varied from − 4° C. down to − 6° C. the weight had only to be raised, in an average of twelve experiments, to a height of 5ft. 6in. in order to break the rail; but when the thermometer rose from + 3° to + 8° C., then the weight had to be lifted for a fall of 7ft. 9in. Similar experiments, conducted in 1860, showed that a difference of temperature from − 4° to + 5° Centigrade was sufficient to greatly influence the height of fall necessary to break the rail. It is not unnatural to suppose that the particles of iron, after being worked at a heat and allowed to cool and set at a medium temperature, should, when that temperature is lowered, get into a state of mutual strain; or that any initial mutual strain should be thus intensified. The toys made of suddenly cooled glass, known as Prince Rupert's drops, are exaggerated instances of a similar action. The outside portions of a bar of whatever size, would evidently cool and consequently contract first of all. The inside portions would also at last cool, but, having kept the outside portions distended, when the inside does cool, it then becomes a question, to be determined by various circumstances, whether it would pull the outside shell into a state of compression, or whether the outside shell would draw the inside into fissures by tension. A somewhat similar explanation is given by Mr. Mallet of the rents caused in the interior of very massive forgings, and this state is probably always induced by the conditions of cooling in a small bar, but with, of course, a smaller range both as to size and temperature. In any case, it is apparent that a ductile, elastic material ought to be less affected by these doubtlessly complicated conditions of tensile and compressive strains. It is, therefore, probable that a hard, harsh, iron would be more affected by frost than a soft ductile iron, and also that the breaking strength of both qualities would be less affected by cold than their extensibility. It is even by no means improbable, though the fact would be difficult, or at any rate very expensive, to prove that the breaking weight, or the elastic limit, or both, of iron, is or are different for every degree of heat. A bar is perhaps cooled down in the rolling shed the medium atmospheric temperature of, say, 52° Fahr. At a lower temperature, at a temperature, for instance, of 32° F., its static breaking weight is increased, but its power of elongation under stress is probably diminished. At, say, boiling point its breaking strength is diminished, but its power of elongation is increased. These remarks to some extent meet the results of Baudrimont and Fairbairn. Unfortunately, Baudrimont has not recorded the elongations, and his experiments were made on wires only one millimetre in diameter when at a temperature of 16° C. Dr. Fairbairn did find that the elongations of plates increased very closely with the temperature, but his experiments are not sufficient in number, to be taken as conclusive; and, as Dr. Percy remarks, many more experiments are required on the action of frost on iron. If it could be shown, for instance, that the crystals of iron expand to different degrees in their different axes, this would probably, *per se*, meet the scarcely-to-be-doubted fact that iron is rendered brittle by frost. As the chain cables of a ship are alternately exposed to the utmost extremes of atmospheric temperature, this question is here of peculiar importance.

The question as to the re-testing of cables that have been in use for a certain time is yet unsettled, but the inquiry is of scarcely less importance than that of the first testing. There are many applications of wrought iron in which it is subjected to impulsive stresses, often more or less accompanied by vibrations, and in which nevertheless, the detail or structure has to conform to certain narrow limits of size and weight. Such is the case with most applications of chains; for instance, to cranes, inclines, forge-slings, &c. Such is the case, also, more or less, with railway axles; the axles of carriages on rough common roads; the gags of helve hammers; the porter bars fixed to the blooms whilst under the hammer; the iron wires of some piano-fortes; and many similar applications of wrought iron. The simple fact that only one-half of the gradually applied stress required to produce the proof strain will, if applied suddenly, of itself produce the proof strain (which if exceeded would injure the piece) goes a long way in explaining the matter. Where great interests of life and property are involved in the safe action of these applications of iron, the irresistible logic of facts has sometimes caused preparatory allowances to be made for these "fatigues of the metal." The axles of the London omnibuses are stated to be always renewed after having run a certain fixed mileage. This system is also carried out with the carriages of the Messageries Générales, the axles of which are changed after having run a limit of 40,000 kilometres. The Honourable the Corporation of the Trinity House entirely renews all the moorings of the light-ships every four years—one-fourth of the number yearly. This limit of time gives the measure of the perfect efficiency of a good cable, well proportioned to its work, and in constant use day and night. Cables in ordinary ships are of course much less, or rather much more slowly, subject to deterioration. We have seen that M. David fixed the time after which a cable in ordinary use should be tested at ten or twelve years. Mr. Macdonald, of the Liverpool testing house, stated, before the 1860 committee, that he would examine a cable after any long voyage—such as to India or Australia. The late Mr. Green, the great shipowner, explained that this was done with the mooring tackle of all his ships. An experienced pilot, Mr. G. J. Thompson, said that it should be made imperative to re-test chain cables every six years, and Mr. Smale fixed this limit at seven years. Mr. J. R. Clarke, however, the chief clerk of the store office, stated that there were many stout cables in store twenty years old. It is clear that it would be very difficult to fix a limit of time that could be applied to all classes of ships. The cables in the royal ships are scarcely so often or so severely tried by use as those of some merchant vessels. A cable might remain good for many years, and yet at last be injured in a single storm. Apart from accidents, such as abrasion on rocks, or against a sharp-cornered anchor stock, or similar causes, there are three main conditions affecting the duration of cables and furthering their progressive deterioration under wear:—1st, the friction and abrasion at the crowns; 2nd, rust and corrosion by the sea water; 3rd, undue strains on the cable, and in excess of the compressive and tensile elastic limits of the materials. The average amount of abrasion and consequent wear at the crowns could only be determined by a statistical comparison of the deterioration of a number of cables, worked under similar circumstances, through a certain period of time. No full observation of this kind seems to have been yet made. The same appears to be the case with the deterioration of iron cables by rust and corrosion. Mr. Mallett has observed, "that the metallic destruction by corrosion of iron in sea-water is a maximum in clear sea-water of the temperature of 115° Fahr., that it is nearly as great in foul sea-water, and is a minimum in clear fresh river-water." It also appears that the finer and more equable the quality of the iron, the slower is its corrosion. The alternative action of the air and the sea-water in ordinary cables must have some influence on their deterioration. Again, at a depth of, say, 100 fathoms, there would be a pressure of nearly 17 tons on the square foot, and this pressure would search out any slight crevice, or any slightly defective weld that had escaped the test. It is at these places that the corrosive action of the water is most felt. It is a well ascertained fact that the spongy mass of mechanically-compressed crystals we call wrought iron, is porous, as water can be forced through it at comparatively moderate pressures. It is also well known that the hydrated oxide of iron we term rust performs the part of an electro-negative element when in contact with metallic iron, which is then electro-positive. When iron is rusting in the air, the moisture of the atmosphere is the exciting liquid; but this voltaic action must be greatly intensified in the presence of sea-water. I have noticed the interesting fact—which deserves more investigation than I have yet been able to give to it—that in the links of a great number of chains the wrought iron is much more eaten away at the sides, where it is in contact with the cast-iron cross-stay. The same action was stated, in a number of the *Times* of last year, to have been observed on the wrought-iron tie-rods in contact with the plates of a cast-iron sea-water tank which burst last June at Woolwich. I had lately occasion to examine a number of old chains, after they had been cleaned, and after the rust had been knocked off with a hammer. All the cast-iron cross-stays, almost without an exception, were slack. Each link was thus temporarily reduced to the condition of an unstayed link, the ultimate strength of which, compared with a stayed link, is generally taken to be in the ratio of 7 to 9. When the cable is in use, the progress of this undoubtedly voltaic action in weakening them will be aided by mechanical causes. The rust generated between the cross-stay and the sides of the link will be more or less washed out by the surge of the cable; a sufficient longitudinal stress would cause the virtually unstayed link to collapse on the stay; the sea-water would again search out the chinks, would again decompose the material; and the deterioration of the cable thus chemically and mechanically weakened, would progressively advance in successive increments that would render its ultimate destruction a mere matter of time. This action would be, of course, more felt in a cable in constant use, such as those of the Honourable the Corporation of the Trinity House; and whether zinking, which is stated by Dr. Parry to prevent rust, would be of any use, or whether other means, which will doubtless occur to many here, might prevent, or at least modify, this action, is perhaps a question worthy of investigation by the able men comprising the Trinity Board. There is, however, no need to search amongst the mysterious forces of nature for the main cause that leads to the ultimate destruction of a cable, or of any other application of iron, under like conditions. The primary cause of the destruction of a cable is simply due to the limit of elasticity of its material being exceeded. All chains are, by their very structure and special uses, subject to jerks and shocks; any country blacksmith knows that a chain that can stand a dead pull, would give way under the same weight if suddenly applied; and we all know that a careless labourer at the winch handle of a crane sometimes breaks down a good chain by a heed-

less jerk. Little more than $5\frac{1}{2}$ tons to the square inch, if suddenly applied, would at once bring on the proof strain of 11.46 tons; and although the dead weight of a cable is its great safeguard—so much so, in fact, that if the cable out of the hawser could be weighted at different parts of its length, this would be an advantage—yet, nevertheless, the safe load of about $2\frac{3}{4}$ tons, under an impulsive stress, to the square inch, must be often exceeded in practice. The safe load under an impulsive stress is in truth rather less, as the assumption is based upon the usual notion, which assimilates a cross-stayed link to a couple of bars.

It appears a paradox to say that the chain is, in one sense, strengthened by a strain in excess of the elastic limit, but such is the fact. The power to bear a static load is indeed increased, as was shown by the experiments cited, before the Committee of 1860, to prove that a cable is strengthened by being broken several times under the gradually applied load of the hydraulic press; and, as was also shown by the performances of the $1\frac{3}{8}$th bars subjected to the same treatment by Mr. Lloyd. The link is, in the first place, mechanically strengthened by being drawn into a lozenge-like shape, as the two sides of each end then act as ties to a very short beam; but this is obtained at the expense of the elasticity of the material—the material of the link is rendered harder. It is a somewhat fanciful analogy to compare the limits of elasticity and of rupture of iron to the organic life of a plant or animal, but it is justified by the common expression that a bar is said to be crippled by an undue strain. If this living force in a bar—these *forces vives de résistance*, as they are termed by Poncelet—if in one word, the work to be done in stretching a bar be expressed (in the English way shown by Mr. Mallet) by multiplying half the static load in pounds required to stretch a bar one foot long and of one-inch cross-section to its limit of elasticity, by its elongation in terms of a foot (T_e); and if the static load required to break the bar be expressed in the same way—by multiplying half the static laad in pounds by the ultimate elongation in terms of a foot (T_r)—we shall then get the power for work expressed in foot pounds, or the structural value of our bar, and shall see the reason that a chain may be crippled for any application in which it is subject to an impulsive force. The short range, multiplied into the high static load required to stretch a bar of hard iron to its limit of elasticity, compared with the product of the long range but low static load required to stretch a bar of soft, ductile iron, will show that a link made of hard, brittle iron will keep its shape much better than one made of soft, ductile iron. A calculation of the work done in rupturing a bar of soft iron will show that, its living force of resistance to rupture is several hundred times greater than the force required to alter its elasticity; and a similar calculation of the work done in rupturing a bar of hard iron will show that the work to be done in breaking it is perhaps twenty times less than that in stretching it to its elastic limit. As any impulsive force is equal to twice the work to be done in producing or consuming it, and as the effort required is less as the distance gone over is greater, it will be seen that, although resilience is a *sine quâ non* in a cable, the strength of the links would be destroyed, and the structural flexibility of the whole cable would be injured by the use of iron too soft; while the use of very hard iron in the first instance, or the ultimate hardening of any iron when its limits of elasticity are exceeded, renders a cable of hard or hardened iron utterly useless for its intended purpose.

There is thus no necessity to have recourse to any theory of the crystallisation of iron under impulsive stresses to explain the gradual deterioration of a cable; but this question of crystallisation is one of the greatest importance and interest; and we may yet learn that the structural value, for many purposes, of a given bar of iron is in some determinate relation to the size of the facets of the crystals of which it is composed. A good cable bar consists of crystals that have been more or less elongated while passing through the rolls; the question is whether these crystals are loosened or separated at their planes of cleavage, or whether the crystalline axes have been transposed, under the undue strains, more or less accompanied by vibration, to which chains in general, and chain-cables in particular, are necessarily subject. There is no well-ascertained instance of any alteration of this kind happening under moderate stresses, but Mr. Mallet appears to believe that a reversal of the crystalline axes takes place when the elastic limit either of extension or compression, and therefore of flexure, is exceeded, and more especially if the piece be not initially in a state of molecular repose. There is every reason to believe in the existence of internal strains in the link of a chain, and more especially at the crowns. But numberless experiments by Dr. Rankine and others, and more particularly by Mr. Kirkaldy, have shown that what is popularly called a crystalline fracture may be given to the most fibrous piece of iron if it be broken under a suddenly-applied load—an effect simply due to the mechanical effect of a sudden stress, and to the fact that any piece of iron is an assemblage of crystals. There is no reason to believe that a magnifying glass—as was, indeed, shown by Robert Stephenson—would reveal any material difference between a bar broken after fatigue of whatever kind, or a bar broken when fresh from the mill. At the same time, the application of a very powerful microscope to the molecular structure of iron has yet to be made; and the history of the first application of the telescope to a very different science may yet find its counterpart in this department of physical knowledge.

Whatever be the internal effect of the lateral contraction induced by excessive tensile strains, it would be of the utmost importance to settle, once and for all, whether re-annealing can restore the living force of resistance of iron, and, therefore, of a cable. Mr. T. M. Gladstone, C.E., recommended this plan before the Committee of 1860. Mr. Smale, then of Woolwich, said that this would be like Burnetising rotten wood. Dr. Noad, in a letter to the *Times*, about eight years ago, stated that he had taken away the brittleness of an old chain by keeping it for 24 hours in a furnace. The late Mr. Glynn recommended that a crane chain should be annealed every three years. At the North Roskear mine in Cornwall, it is stated by M. Moissonet that the pit-chains are withdrawn from the shaft after every six months' use, are rolled in a heap, then covered with a sort of cylindrical furnace, and brought to a red heat. According to an account translated from the Russian into the *Polytechnisches Centralblatt*, the chain cables for the Russian government, after being brought to a dark-red heat immediately after testing, are then tarred—a plan which is said to prevent rusting, as the tar thus takes a firmer hold on the iron. But many things may be done with charcoal iron. Baudrimont appears to believe that all metals only acquire determinate qualities by proper annealing, and that a cherry-red heat is necessary for annealing wrought iron. According to the experiments by the Franklin Institute, wrought iron is perfectly annealed at a clear bright red. The experiments of both Baudrimont and the Franklin Institute show that the ultimate tenacity of iron is considerably diminished by annealing, but, unfortunately, in neither case was the elongation noticed. Poncelet has shown that his co-efficient, T_e, of elasticity is increased with annealed iron, but that the co-efficient of rupture, T_r, is diminished. This refers to wires, but no complete experiments appear to have been yet made on the effect of annealing on bars. It is a question whether the extra ductility conferred on the links by the process of annealing would not, while rendering them more ductile, at the same time lead to their changing their form. At any rate, at least some of the cast-iron cross-stays would be rendered less able to withstand distortion. At the same time, the question ought to be settled, and to cables comparatively uninjured by corrosion, the process might prove of great value. The conditions of size in a cable are peculiarly favourable to the use of annealing. Great as the advantage would be in the successful application of annealing to large forgings, there are several well authenticated instances of massive crystals being developed in the interior of the mass by the long-continued action of red heat. General Morin thus mentions an instance of the production of crystals, with facets from 4 to 5 millimetres in breadth, in a charcoal iron bar originally of fine, soft, fibrous, texture.

Tied as we are in testing cables within a narrow limit, which if exceeded in either direction would, on the one hand, either impair the efficiency of the test, it is clear that the most thorough accuracy is required in measuring the proof stress. Unfortunately, it is not always the case that this accuracy is obtained. The stress exerted by the machine of M. David, of Havre, was shown by the French government to be taken too high. The appliance for the measurement of the stress exerted by the Liverpool corporation testing machine, was a few years ago shown by Mr. Mallet to give a result of nearly $9\frac{1}{2}$ per cent. error in excess. Some of these machines consist of a powerful windlass purchase, but we will confine our attention to the direct-acting hydraulic press, the application of which to the testing of chain cables, by the late Sir Samuel Brown, may be said to have rendered the iron cable a practicable thing. There are three distinct ways of measuring, or at least approximately measuring, the stress exerted by the press plunger. 1st. A small valve is fitted to the cylinder and furnished with a steel yard and adjustable weight. In large machines this is, for the sake of convenience, carried to a distance from the press, the water being conveyed in a small pipe. 2nd. A Bourdon gauge is attached in the same way, either direct on the cylinder, or it is placed in communication therewith by means of a small pipe. 3rd. The other end of the chain being tested is attached to the head of a bent iron lever, the power of which is multiplied by a system of levers balanced on knife edges. The plan of measuring the stress exerted by the press plunger, by means of a weighted valve, is liable to several objections, as was pointed out many years ago by Professor Peter Barlow, more recently by Professor Rankine, and by Mr. Bowman in his evidence before the 1860 committee. In the first place, the relative proportion between the pump plunger and the valve is necessarily great; and a simple calculation will show that a hair's breadth more or less to the valve, would make an important difference. In the next place, the friction of the leathers and the weight of the plunger are not taken into account; the gross load on the plunger is, in fact, given as the useful work at the end of the piston-rod. Some experiments made by Professor Rankine, whose name is a sufficient guarantee in matters of this kind, have shown that about one-tenth should be deducted from the pressure in the hydraulic press, merely for the friction of the press plunger. The real, the useful work exerted at the end of the plunger on the chain is thus more than 10 per cent. less than is given by the pressure of the water. An error in the opposite direction will be made by conducting the pressure of the water either on a weighted valve or on a Bourdon gauge, and this error will vary with the diameter of the pipe, the number of bends, and the other losses of effect in a stream of water passing through a pipe, which are well known to engineers. The load on a safety-valve is always an unreliable datum for computing pressure; a Bourdon gauge is much more delicate, but, in this case, its indications are erroneous, unless proper allowance be made for the friction of the leathers and the weight of the plunger. The most exact means yet employed for measuring the stress created by the plunger on the chain consists in the use of a system of balanced levers, according to the plan adopted at H.M. Woolwich and Portsmouth dockyards, and by Messrs. Brown and Lenox. The press at Woolwich is also furnished with a weighted valve, according to the plan just mentioned, and in addition to the system of levers. The lever scale is perfectly sensible to a few pounds, but the valve scale will scarcely move with a load of two tons, and it is less and less sensible as the loads increase. The balanced levers are perfectly accurate, but the apparatus is rather expensive. At the last Worcester Show of the Royal Agricultural Society, a certain apparatus (not patented) was exhibited for testing the draught of Fowler's six-furrow steam-plough, and it appears to me that a modification of this dynamometer might be employed for registering the stress on a cable. It consisted essentially of a cylinder and a piston, on one side of which was a volume of water in communication with a Bourdon gauge. The water was enclosed in an elastic diaphragm fixed to the piston and to the cover, and the gauge was necessarily marked according to the results given by weights gradually applied. By shrinking rings on the outside, or by straining on a coil of wire, the cylinder could be made to stand any amount of pressure required, and, if adjusted with the cross shackle pins at the opposite ends, at right angles to each other, in order to prevent any torsion, and also by the adoption of other simple means, such as the use of steel, that will occur to those now present, a light instrument of probably very great delicacy would be obtained.

When a long length of cable, say of seventy-five fathoms, is being tested, there is another influence that will, in some cases, affect the result. If we take

the comparatively light one inch cable, we find that it weighs 58lbs. per fathom, so that the whole length will weigh nearly two tons. The last link at each end will have to stand a down pull of nearly one ton in addition to the longitudinal stress of 18 tons. This, however, would probably be compensated by directing the hammer test more towards the centre portions of the cable, and the *vis viva* of each blow will be absorbed by the elasticity of the metal, the deflection of each link struck, and by the combined weight and resilience of a certain portion of the cable within the range of each blow. It may here be noticed that in testing the effect of impact on beams, Mr. Hodgkinson used a 4lb. leaden cushion in order to partially deaden the jar of the blow. In a leading article of one of the engineering journals, in May last year, giving an account of Lloyd's proving house, it was proposed that "a falling weight, to be released by a trigger tripped by a long cord," should be employed instead of the hammer, in order to prevent any accident to the operative, through the flying of the cable or chip of the cast iron cross-stays. This weight could be made to slide overhead in the same vertical plane as the cable; and by letting it fall from heights determined for each diameter of cable, the *vis viva* employed could be measured with approximate accuracy. This would be on a par with the plan adopted in numberless instances, as we have seen, by our scientific neighbours the French; and similar measures might perhaps be used to measure the blow required to carry out the fracture test.

The application of known impulsive force as a test is of the utmost value, more especially when, as with cables, the object tested will have to undergo such forces in practice. If some plan could be devised for easily and accurately submitting the whole length simultaneously to a sudden instead of a static load, this would be of great importance. In the mean time, the hammer-blows are the tests for the resilience of the cable. In doubtful cases Professor Daniell's acid test might be of value in examining the structure of the fractured sections of the two or three links that are usually broken up. A great number of experiments on the specific gravity of iron have shown that it would be dangerous to make deductions as to the qualities of a specimen of wrought-iron worked by one metallurgical process, and to then apply these results to a bar produced by another mode—for instance, to compare in this way a rolled bar with a hammered bar. At the same time there is a remarkably close, though not perfect, correspondence between the specific gravity and the quality of the specimens. Mr. Kirkaldy found that the specific gravity of iron was even decreased by being much strained—at any rate by tension. It is very easy to obtain the specific gravity of any substance like iron; and whether the physical facts that, 1st, the gravities of for instance, No. 3 bars, bear a pretty constant relation to their qualities; and that, 2nd, the specific gravity of wrought-iron generally is diminished by tensional straining; and, 3rd, that it is considerably increased by annealing, might be used in practice for testing the quality of the iron, or the deterioration through wear of a chain, is at least worth an inquiry.

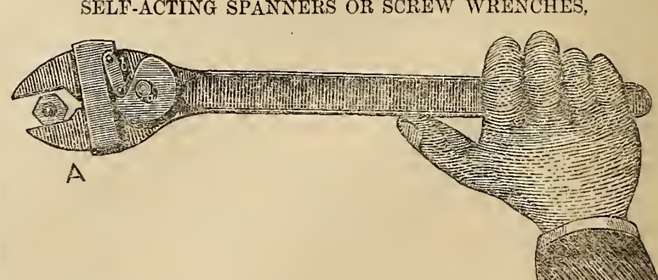
The physical conditions involved in the construction, the use, and the testing of anchors, differs so materially from those of chain cables, that the two subjects must be separated in an examination of this kind. But there can be little doubt that a sound and general system of testing the mooring tackle of ships will bring about the same improvement in the quality of chain cables and anchors, as the trials at Shoeburyness have already effected in the quality of rolled plates; and the effect will indeed be produced by somewhat similar causes.

The Madras Irrigation and Canal Company.—It appears from the report presented to the tenth ordinary general meeting on the 28th ult., that although the directors are unable to report to the shareholders that any material improvement has taken place in the supply of labour for the prosecution of the works in India since the date of the last general meeting, they are fully justified in stating that, looking to the means that have been available during such period, the actual progress made has, upon the whole, been satisfactory; and that the confidence expressed in their former reports in the soundness and ultimately profitable character of the complete scheme of works now secured to the company intact, has not only remained unshaken, but has received strong confirmation. An assurance is also received from their chief engineer, that the commencement of the realization of returns upon the capital expended will be arrived at during the present season; and though such commencement will be upon a limited scale only, it may safely be assumed that the amount of realized returns will, during each subsequent year, be satisfactorily added to, until the whole project has been completely developed. It is notorious that throughout the whole of India the supply of labour has lately been found to be unequal to the extra demand created for it in various ways, and that its cost has therefore been largely added to. The price of grain and other products of the soil, and of food generally, has also advanced considerably. These facts are authoritatively vouched for in the financial statement for the year 1864-5, just made by Sir Charles Trevelyan, the financial member of the Government of India, who there asserts that, during the past year, every public work under execution or contemplation in that country has been affected and delayed by the scarcity of labour, its increased value, and the great rise in the price of provisions. It is evident, therefore, that, under these circumstances, this company cannot hope to escape, and must be prepared to meet a larger expenditure than was at first anticipated. Nevertheless, this increased outlay will be fully counterbalanced by the increased value of the products of the soil to which, in accordance with the terms of the contract, the price of that contract, the price of that water will be regulated. The Directors have received advices from their officers in India, which represent it as probable that the number of labourers employed will be presently greatly added to. Endeavours have been energetically made in every direction to secure the services of workmen. Agents have been engaged in the adjacent districts; the chief minister of the Nizam of the Hyderabad territories has been induced to issue a proclamation authorising the Nizam's subjects to take employment under the company, and a contract has been entered into, under which 2,000 practised excavators are to be despatched from Madras, and that number afterwards maintained upon the company's works for a period of two years certain. These efforts, the directors are assured, will not be relaxed, but continued with vigour. With reference to the progress made and the present state of the works, it appears, from the report, that the Anicut across the Toombuddra River at Soonkasala has been repaired in the part where it was slightly breached last year, and it will, according to the reports of the chief and executive engineers, be completed this season before the period at which the floods usual come down. This structure has been strengthened by the addition of an artificial apron at its foot on the lower side, the rock forming the bed of the river there being, as shown by the effect of the overfall during the last floods, liable to displacement. The masonry under-sluices of this Anicut, and the large masonry headsluices of the main canal, have likewise been added to, and revolving shutters of much greater strength and durability have been substituted for for those originally designed. The cost of the foregoing Anicut and sluices has, from the causes before mentioned and the additions now explained, exceeded the original estimate, but they are described by the chief and executive engineers as very substantial works. The first section of the main canal, 17¼ miles in length, extending from the Anicut to the aqueduct across the Hindry River, will, it is anticipated, be ready for the reception of water during the present month. The breach in the embankment at the sixth mile has been effectively repaired, and the whole of the embankments have been largely added to, strengthened, and re-vetted with stone along their entire length; indeed, the directors are assured that every precaution has been taken, in accordance with their instructions, to render the work as secure as possible against future accident; additional public means of crossing the canal have been likewise provided or undertaken. It will be obvious, under these circumstances, that the first estimate has been found insufficient for this section of the main canal also. The chief engineer reports that the land commanded by this first section of the canal, about 2,270 acres in all, can be irrigated, and that it may fairly be assumed that at least 1,000 of such acres will receive irrigation from the company's canal during the coming season. This commencement of irrigation, although small, will be important and of great value to the company, inasmuch as it will exhibit to the native community of the adjoining districts the certainty of a supply of water being available, and thus they will be stimulated by self-interest to prepare for that supply to their own land in the ensuing year, by which time many additional miles of the main canal, with the minor channels of distribution, will be completed, and a large spread of land will be brought under command. It is interesting to know that during the last season a small patch of land, about 20 acres, was irrigated from the canal at about its fifth mile, and the crops produced thereon are described as being very superior and luxuriant—indeed, so much so, that the ryots or cultivators resident in the neighbouring villages, and on the opposite side of the river, visited the irrigated fields, and exhibited great admiration and interest. The Hindry aqueduct has had a second third of the entire breadth of the whole of its arches added, and now requires only the remaining third of such arches for its completion. It is in a state fit to convey a large body of water to the lower portion of the canal if necessary. This work has been, so far, executed in a very substantial and satisfactory manner. The main canal, from the aqueduct last described to the end of the cutting at Mittacondal, that is, to the 73rd mile from Soonkasala, is still under construction, though approaching completion in many parts, the Mittacondal cutting itself in a finished state. Rock of an extremely hard nature has been found to exist at spots on this part of the line to a greater extent than was anticipated; nevertheless, the chief engineer states that, had the supply of labour been more abundant during the six months now reported upon, the whole work might have been executed by the end of next month, or at least so as to have allowed water to pass down to and through the cut sufficient to irrigate the 65,000 acres commanded in the Boannassy Valley, and a large spread of land also comanded by the canal below, at the head of the Koondair Valley; but it is now manifest that so much work cannot be effected in time to allow of perfect irrigation in that locality during this year. The postponement of irrigation upon a large scale to another season, caused by a want of labourers, though unavoidable, is certainly matter for regret. The embankments along the fifty-five miles of canal now under reference have been strengthened, and will be revetted with stone wherever a spread of water occurs, and where such revetment is found to be in any degree necessary. Again, in some places, in consequence of the extreme shallowness of the soil, and the very great expense attendant therefore upon the formation of the embankments as originally designed, those embankments have been replaced by a stone wall. Increased public accommodation for crossing the canal has also been

provided. The numerous masonry culverts, calingulahs, bridges, and irrigation sluices along this section of the canal have made good progress, many having been finished. One of the executive engineers in charge of this division has pointed out how some 2,500 acres of land may be irrigated during the present year from the natural drainage of the country, if stored in the canal; his plan appears feasible, and will, it is stated, be acted upon if found practicable. From the 73rd to the 148th mile, *i.e.*, from the Mittacondal cutting down the Koondair Valley to the junction of the Vaikaloor and the Koondair Rivers, the main canal is under construction, and a very satisfactory amount of work has been performed between the 72rd and the 103rd miles. The progress made in the remaining 45 miles has been slow, but measures have been adopted to induce more vigorous efforts in future. Special attention has been turned to the channels projected for irrigation in the upper part of the valley, as it is desirable that they should be first completed, so that the land may be supplied with water immediately it can be conveyed along the works above the cut, and progress upon locks and the Navigation Canal along the valley will theretherefore be made subservient to the completion of those channels, that is to say, all the available labour will be employed upon the latter in preference to the former. The plans and estimates of the next twenty-five miles of the main canal, that is, from the Vaikaloor to the Pennair River, have not yet been submitted to Government, but by the last advices they were on the point of completion, and about to be forwarded for sanction; those for the following ten miles and for the anicut across the Pennair were, at the date of the same advices, before the Government for approval, whilst those for the remainder of the line to Somaishwarum, being about fifty miles, were at the same date under preparation. The anicut at Somaishwarum has been pushed forward with vigour, and should, the chief engineer reports, be sufficiently advanced by the end of this year to afford a supply to the channel intended to be led from it, and which by that time will, he states, be ready to receive water to a limited extent. The plans and estimates of a portion (about ten miles in length) of the canal leading from this anicut through Nellore to the coast have been re-prepared after a complete re-survey of the country, and were in March last placed before the Government for their approval; upon the receipt of this approval, the work was to be at once entered upon. An apparently advantageous site for the storage of the floodwater of the Pennair River, whereby a large extension of irrigation may be effected in Nellore, on the northern side of the last-named river, has been partially surveyed, and will, it is thought, be found to be highly desirable. Should such be the case, plans and estimates of the necessary dam and sluices will be prepared and submitted to the Madras Government, so that no time may be lost before the execution of the work itself is taken in hand. The site for a reservoir upon the River Buddra, near to Luckovally, has since been recommended by the chief engineer; but previously to according their sanction of the work, the directors have called for carefully prepared plans and estimates of the dam, and of the discharge and escape sluices, that the most careful consideration may be given to them before final adoption. Another site, said to be equally favourable with that at Luckovally, has been discovered upon the Toonga River, and is now under survey. These two proposed tanks on the Toonga and Buddra Rivers will be sufficient for the full supply of the section of the company's scheme now under construction. The upper or Western division of the Toombuddra scheme, including the Bellary district, and to which great value is attached by all acquainted with the country, is still under detailed survey, though much and satisfactory progress has been made therein. The directors continue to entertain the opinion they expressed in their last report of the desirableness and importance of this division of their scheme, and the belief that it will greatly enhance the value of the other portions; at the same time they are desirous of procuring the most perfect and reliable data regarding it, before commencing constructive operations.

Plumbago Crucibles.—Mr. J. C. Brough, in a recently-published article upon a visit to the works of the Patent Plumbago Crucible Company at Battersea, gives some very interesting particulars and data in connection with the subject of crucibles generally, and a very clear description of the several processes and manipulations carried on at the works of the Company. Mr. Brough informs us that the bulk of the graphite (crystalline and amorphous) used at present comes from Germany, principally from Griesbach, near Passau. Both varieties are used in the manufactures of the Company; the crystalline for crucibles, and the amorphous for polishing powders; for it appears that the company prepare a good proportion of the raw material for domestic purposes, as "ordinary black lead." The consumption of Ceylon graphite at the Battersea works has had an extraordinary effect upon the price of the article. When the Company commenced business it cost about £10 per ton, but now it cannot be bought at double that price. In Ceylon we hear that applications to dig graphite are daily on the increase, notwithstanding the rate of 14*s*. per ton which has to be paid as royalty at the Colombo Cutcherry. In the manufacture of plumbago crucibles, the mixing process is considered to be the most important operation. At the works of the Company the following is the description of the process as there carried out:—A number of large bins, each containing a distinct variety of clay in powder or a certain quantity of plumbago, are ranged round the room. Upon the proportions of these several ingredients taken to form the mixture, or "metal," as it is technically termed, the quality of the crucibles depends. The actual proportions of Stourbridge and other clays used are, however, kept secret. The ground graphite having been mixed with clays, the whole is wetted with a sufficient quantity of water and allowed to soak for some time. Having been "pugged" in the mill, the tempered "metal" is formed into blocks and then placed in a store-room, where it is allowed to remain for several weeks. Proceeding to the potter's room, where the crucibles are fashioned, we can there watch the growth of one large crucible. The "thrower" takes the necessary quantity of "metal" and submits it to the operation of "wedging," which consists in tearing or cutting it into two pieces and striking them together again with great force. This he repeats until the metal becomes perfectly tractable. He then dashes the mass upon the revolving disc of his lathe and presses it with his wet hands till it assumes an irregular conical form. He then makes it take a variety of forms with the object of getting rid of all air bubbles. It is impossible to follow the mass through its numerous changes, but suddenly, when we least expect it, it takes the shape of the crucible. This shape is very rude at first, but under the skilful hands of the thrower it soon becomes beautifully symmetrical. A wire guide is fixed at a certain height above, and at a certain distance from, the revolving mass, and to this the thrower gradually brings the edge of the crucible. With this simple guide he can make a dozen pots resembling each other so perfectly in shape and size, that the most experienced eye can hardly detect any variation in them. After the pots have remained sufficiently long in the drying-room, they are then packed in cylindrical cases of fire-clay called "seggars," which are piled one above the other in the kiln, and are luted closely together. These seggars protect the goods from the action of the air, which at a high temperature would have the effect of whitening their external surfaces, and so rendering them unsightly. The crucibles come from their fire-clay cases exactly as they are sent out from the works, that is, without the fictitious polish and smoothness generally given by Continental makers. From the kiln the goods are conveyed to the store-room, or to the packing-room, if they have to be shipped at once. The goods are nearly always packed in old sugar hogsheads, which are strong, large, cheap, and plentiful. Amongst the specialties in the way of crucibles made by the Company, may be mentioned that which is of the pattern supplied to the Royal Mints, intended for melting 600 pounds weight of silver. Another is a plumbago pot, made especially for zincing the Armstrong shot, and which will hold 800lbs. of molten zinc. The medium sized plumbago pots now so extensively employed for melting silver, gold, copper, brass, and malleable iron, are, of course, the most important products of the works. All the pots are numbered according to their contents, each number standing for one kilogramme, or a little over two pounds; thus—a No. 2 crucible contains two kilogrammes; a No. 3, three kilogrammes, and so on. We may mention as an instance of the value of the plumbago crucibles, that the manager of the refinery of Messrs. Brown and Wingrove, the refiners to the Bank of England, states that the patent plumbago crucibles never cracked, but gradually became thinner until a point was reached, when it would be unsafe to trust a charge in them, and that 50,000 ounces of silver and upwards had been melted in one 1,000 oz.-pot.*

SELF-ACTING SPANNERS OR SCREW WRENCHES.



These spanners are a contrivance of Mr. L. Schwartzkopff, of Berlin, whose steam hammer we illustrated in The Artizan of September, 1862. The main feature in these spanners is the simplicity of their construction, as they can be used for nuts of all sizes by simply applying them to the nut and turning a hand lever, without any special mechanism for *setting* them being required. The chuck *a* is fixed on the hand lever, and connected with the small lever *b*, which is set in motion by the moveable jaw A being pressed against one side of the nut. By this means the spanners will close themselves, irrespective of the gauge of the nut, so long as the latter can be contained between the two jaws.

* Illustrated notices of the plumbago crucibles will also be found in The Artizan International Exhibition Supplement, 1862.

REVIEWS AND NOTICES OF NEW BOOKS.

The Exhibited Machinery of 1862. A Cyclopædia of the Machinery represented at the International Exhibition. By D. K. Clark, C.E. London: Day and Son.

The author of this book, Mr. D. K. Clark, has been long well known as an engineer of eminence, and as an authority in his profession; and he was, as our readers know, the superintendent of the machinery department in the Western Annex of the International Exhibition, where an unequalled display of the best machinery was gathered together, and worked during the Exhibition. He has, therefore, had ample opportunities for examining the machinery, and he has matured his observations in the volume before us. The title of the work exactly describes its nature, as a cyclopædia of machinery. Upwards of 1,100 machines, and portions of machines, have thus been accurately noticed, or described in detail; and after a careful examination of its contents, we are bound to state that it forms a complete and compact cyclopædia—carefully, moderately, and impartially written—which will prove valuable as a text book for students, and as a work of reference for engineers. The greater portion of the work is necessarily descriptive, as the author has judiciously refrained from swelling his pages with needless commentary—which is better adapted for the ephemeral pages of a newspaper, forgotten as soon as read—and has confined himself mainly to descriptive analysis, from which readers may generally form their own conclusions. He has, however, in addition, supplemented the descriptive matter with several chapters, in which the machinery is ably analysed and passed in review, for the purpose of defining the course of improvement, which will be highly appreciated for their useful practical character.

In the arrangement of the work, the author has, in general, followed the classification of machinery adopted by her Majesty's Commissioners for the International Exhibition, and comprehended in the official catalogues. He treats successively of Railway Plant, in relation to which he fully describes the improvements that have been made in locomotives since 1851, and particularly for the purpose of consuming coal without smoke; then the Machinery for Manufacturing Textile Fabrics, in which the adaptation of cotton machinery for the spinning of the Egyptian and other short staples in lieu of the long staple cotton, derived till within the last few years from America, is fully described; as well as the advances that have been made in weaving, and in the treatment of other fibres; next comes the manufacturing machines and tools for working in iron, wood, and other materials, which are extremely various, and embody many improvements in the working of materials during the last ten or twelve years; and, lastly, machinery in general, which is also very various, and comprises steam-engines and boilers, hydraulic machinery, pneumatic machinery, cranes, and other objects.

In the concluding chapter on locomotives, Mr. Clark ingeniously accounts for the variety of practice on English railways, and, we believe, no one is better qualified to form a judgment.

"It appears," says our author "that the exigencies of continental railway traffic have demanded a greater variety of locomotive engines than have been found necessary in the United Kingdom. Trains on the Continent are heavier, speeds are lower, and, more than all, inclines are steeper. Whilst, then, the marks of progress in English engines are to be found mainly on refinements on the normal types, foreign engineers have discarded our traditionary types, and have specialised in more than one direction. In England engineers have arrived at higher speeds, with more powerful boilers and increased driving or adhesion weight. The means of satisfactorily balancing the reciprocating and revolving machinery, theretofore the bane of the outside cylinder engine—by counterweighting the wheels and steadying the engine—having been discovered and carried into practice since 1851, so that the outside cylinder engine, properly balanced, runs even more steady than the inside cylinder engine, locomotists have employed outside cylinders with complete success. Outside cylinders have not, however, been employed for the heaviest work. The inside cylinder is retained for the six-coupled goods engine, and it is not likely to give way to the outside cylinder for that class of work. But for passenger traffic, with four coupled wheels, and the lighter traffic of collieries and other private establishments the outside cylinder is well suited and is extensively applied. It is, however, to be explained that the advantage of the six-coupled engine is limited to the old and the comparatively straight lines of railway, on which the destruction of cranked axles is not rapid, and the wear and tear of tires not severe. For lines with prevalent curves, the four-coupled outside cylinder engine surpasses in efficiency and economy the six-coupled—running on curves with greater facility, utilising the adhesion weight better, and being subject to less tear and wear. Hence the six-coupled engine, with inside cylinders, is to be found chiefly on the southern and north-eastern divisions of the London and North Western Railway, the Great Western, the Midland, the South Eastern, the London, Brighton, and South Coast, the Great Northern, the South Eastern, and the Edinburgh and Glasgow Railways—in short the older and straighter lines (the Great Northern, though a newer, is one of the straighter lines). On the contrary the outside cylinder with single and with four-coupled wheels are to be fonnd on the northern division of the London and North Western Railway, the Lancaster and Carlisle, Caledonian, Scottish Central, Scottish North Eastern, and Great North of Scotland, which are newer lines, and have many quick curves. The London and South Western and the Great Eastern Railways, it is true, are of the older and straighter class, and are stocked or being stocked with outside cylinder engines and their correlatives, straight axles, but the former line was initiated with outside cylinders by the great apostle of straight axles, Joseph Locke, who was the engineer-in-chief of the line, and who imported his experience of the broken and short-lived cranked axles, and the durability of the straight axles on the original Grand Junction (London and North Western Railway, Northern Division), and resolved, like a man of sense and experience, when he had a good thing to keep it. The Eastern Counties, again, was originally stocked with inside cylinder engines; but the engines having passed into the care of Mr. J. V. Gooch, who brought from the London and South Western Railway his experience of outside cylinders, the stock received an infusion of outside cylinder passenger engines; and having, at a later period, been placed under the care of Mr. R. Sinclair, who brought with him likewise his experience of outside cylinders—first, from the Paris and Rouen Railway, with Mr. Buddicom; second, from the Caledonian Railway, as chief engineer and locomotist;—the stock of the Great Eastern received an additional infusion of outside cylinders, mostly with four-coupled wheels, on six-coupled wheels. A prominent exception amongst the newer and more sinuous lines is the North British Railway, where inside cylinders have been universal; but they were introduced by the chief engineer who was also the engineer-in-chief of the Edinburgh and Glasgow Railway—a first-class line for directness and flatness—where inside cylinders had answered perfectly well. It has nevertheless been found that, on that railway—the North British—the wear of six-coupled engines is excessive, that the wear of four-coupled engines is much less, and that the latter do more work with more ease and less cost of maintenance, and, doubtless, the outside cylinder and straight axle will find their way on that line."

Mr. Clark justly criticises the prevalent practice of locomotive engineers of overcrowding their boilers with flue-tubes, as to which and other questions of locomotive engineering we believe no one better qualified than Mr. Clark to express an opinion.

The most modern systems of permanent ways (of which there were exhibited a great variety) are fully noticed. Mr. Clark is of opinion that the suspended double-headed rail is likely to be universally adopted in some one or other of the forms in which it has been exemplified.

Turning to the textile machinery, the display of cotton-spinning machinery at the Exhibition demonstrated, in an unexpected manner, how good comes out of evil. The stoppage of the ordinary supplies of the raw material from the Southern States of America has, in a forcible way, directed the attention of manufacturers to the necessity of dealing with the shorter staples of cotton from Egypt and India.

"In connection with the demand for Indian cotton, general attention has recently been directed to India for the production of that article; and though Indian cotton was open to the objection of shortness of staple, yet, when our manufacturers made it their business to look the difficulty in the face, it was found quite possible, and it was proved perfectly practicable at the Exhibition, to work up staples of the shortest sorts. In fact, the necessity of dealing with Surat cotton, and making the best of it, has caused people to learn to spin. 'Twenty-fours' was the finest count they were in the habit of spinning from Surat staple, with a loss of material by waste amounting to 25 per cent., sold for manure at a shilling a ton; they can now successfully spin an excellent round thread of double the fineness, "fifties" is the count, and there is very little doubt that, with the aid of an improved cultivation, if the inducement continues, "sixties" and "seventies" will be reached in time."

After giving an elaborate account of the various spinning machinery exhibited, Mr. Clark concludes that "The progress made since 1851 in cotton preparing and spinning machinery may be summed up in four words—improved workmanship, better and more extended automatic action, higher speeds with increased productive power, and better quality of production."

He afterwards summarises, in concise terms, the advance that has been made in the construction and performance of spinning machinery.

Looms and other weaving machinery have been treated in considerable detail; the section devoted to looms is introduced with an interesting historical account of the calico and jacquard looms.

In an interesting notice of the sewing machines exhibited—comparatively recent inventions—Mr. Clark informs us that in some of the manufacturing establishments in America, sewing machines are regularly turned out at the rate of from 400 to 800 per week, and that the estimated total number of sewing machines in use in America is 300,000, of which about 75,000 are employed by private families.

After an elaborate analysis of the various tools and other manufacturing

machines exhibited, with respect to which we can just refer to the general adoption of the box or hollow casting for tool frames, introduced by Mr. Whitworth, and the bread-making machinery of Dr. Dauglish, there follows a detailed accouut—we might say a complete treatise—on the steam engines exhibited.

"Amongst the great number of steam engines exhibited," says Mr. Clark, "in the Westeru Annex alone—about seventy-five in number, of which there were about sixty stationary engines, besides the display of engines in the agricultural departments—the horizontal was the prevailing type of engine. The horizontal arrangement is obviously the simplest, the most compact, and the steadiest, other circumstances being alike; and, with compactness, it combines facilities for ready and minute supervision, and for general attendance and maintenance. The advantages of the horizontal system are so well understood, and the Exhibition showed that they were so generally acknowledged, that it is unnecessary now to say more for the system than to intimate the fact.

"Of the exceptions to the horizontal arrangement, the most conspicuous were the beam engines in the English section, constructed to work the sugar mills. These magnificent specimens of workmanship have already been noticed in connection with the mills; and whilst it may, perhaps, be assumed that there is no decided advantage in the six-column beam engine for the performance of real work over the horizontal engine, which is minus the beam, it unquestionably commands the preference in its superior presence and its graceful movements.

"Whilst, in a very few instances, English constructors showed a desire to improve the economical performance of the steam engine, their engines in general testified to a feeling of absolute indifference to economy of steam or fuel, and probably, in some instances, to ignorance of the conditions on which economical working is to be established. In one conspicuous instance—a pair of high speed horizontal engines, exhibited by Messrs Gwynue and Co.—the valves had been set without any lead, and the steam was admitted up to the end of the stroke of the piston. The consequence was, that an enormous back pressure, amounting to 40 per cent. of the whole positive pressure, was exerted against the piston, by reason of the difficulty of escape for the exhaust steam. The valves were during the Exhibition slightly readjusted, when the loss by back pressure was reduced to from 25 to 30 per cent., still an excessive resistance. In another instance, that of Messrs. Burgh and Cowan's trunk engine, the back pressure amounted to 70 per cent.—nearly three-fourths of the whole positive pressure.

"The manifest concern of the foreign exhibitors to construct their steam engines on economical principles was, on the contrary, remarkable; and it is probably sufficiently accounted for by the costliness of fuel abroad. At home, nevertheless, they are sounding the alarm over our diminishing coalbeds. The key-note has been struck by Sir William Armstrong at Newcastle; aud though eminent colliery owners, as Mr. Nicholas Wood, do not apparently sympathise with Sir William, pointing with confidence to the vast unexhausted seams extending under the ocean, the alarm, well sounded, may do good, and cannot possibly do any harm. Of the two-and-thirty stationary engines exhibited in the English section, not more than half-a-dozen had clothing on their cylinders, and the most of these, remarkably enough, were clothed by the agricultural engineers. Nor is it too much to say that, taken generally, the engines exhibited by the agricultural constructors were better designed and detailed, and more thoroughly constructed, than those of most other engineers.

"Locomotive engineers, particularly foreign engineers, appear to have overrated the abstract value of heating surface. Scarcely alive to the great importance of free passage for currents of water in intimate contact with the heating surface, whether of the fire-box or of the tubes, many engineers have reduced the width of the water spaces around the fire-box to a minimum barely sufficient to preserve the plates from being overheated, they have likewise placed the flue-tubes so near to each other, and in such large numbers as to defeat their object of increasing the steam-producing power of the boilers, because they have rendered it impossible for the water, crowded with struggling globules of steam, to reach the surface of each tube, and to be evaporated. Tube surface under such circumstances is inactive, and ultimately becomes mischievous, for the sediment deposited by water in boilers will, if not scoured out, coat the tubes and block up the interspaces altogether. The greatest number of tubes known to have been applied in England are the 305 tubes of the Great Western express engines of the class of "The Lord of the Isles," exhibited in 1851. In these tubes, 2in. diameter, are placed only $\frac{1}{2}$in. apart, and are not so effective for evaporation as the tubes of earlier engines on that line which were fewer in number, but were placed at from $\frac{5}{8}$ to 1in. clear.* In the English engines exhibited in 1862, the greatest number of tubes was 215, by Messrs. Beyer, Peacock and Co., $\frac{9}{16}$in. clear; and the North Western Company applied 214 at $\frac{1}{2}$in. clearance. The best English practice exhibited is to be found in the North Western engine, "The Lady of the Lake," Mr. Connor's engine, by Messrs. Neilson and Co., and Mr. Sinclair's engine; all of which, singularly enough, have identically the same proportion—192 tubes, $1\frac{7}{8}$in. diameter, $\frac{3}{4}$iu. clear, placed in a barrel 3ft. 10in. inside diameter. The goodness of these proportions is proved by the very satisfactory performances of the engines under very different circumstances. The greatest number of tubes exhibited in the foreign engines is 356 tubes, with $\frac{7}{16}$in. clearance, in the heavy gradient engines on the Northern Railway of France. The drawings further exhibit the twelve wheeled goods engine with 464 tubes, having $\frac{9}{16}$in. clearance. These proportions will disappoint the expectations of the projector; and the experience of a few years will, it is presumed, modify the extreme views about heating surface entertained on the Continent."

In his notice of steam boilers, our author propounds what he has called the projectile theory of the violence of boiler explosions, according to which the peculiar violence attendiug many explosions is to be ascribed to the projectile force acquired by the particles of water and steam within the boiler, by reason of the suddenly developed expansive force of the steam generated in the boiler, concurrently with the sudden fall of pressure produced by the sudden escape of steam from the boiler, at the locality of the original failure, or by the sudden enlargement of its volume from any cause, as the collapse of a flue, for example. The theory is ingenious, and we give Mr. Clark credit for the manner in which he has fortified the theory with examples of its application.

In an elaborate analysis of the merits and performances of some of the steam pumps, Mr. Clark enters in considerable detail into the comparative merits of the steam pumps exhibited by Messrs. Easton, Amos, and Sons (the Appold pump), and by Messrs. Gwynne and Co. This looks likes a renewal of the old discussion, in 1851, between Mr. Gwynne and Mr. Appold, who then exhibited their respective pumps. The main distinguishing feature of these pumps consists in the form of the blades, which in Gwynne's pump were straight, and in Appold's were curved. The jury, in 1851, concluded, from careful experiments conducted by means of a brake, that whilst the greatest efficiency of Appold's pump in terms of the power actually applied to the pump-shaft was equal to 68 per cent., that of Gwynne's pump did not exceed 19 per cent. The extraordinary inferiority of Gwynne's pump with straight radial channels, compared with Appold's with the curved blades, appears to have led to the introduction of a short curve at the end of the blades in the pumps now constructed by Messrs. Gwynne and Co.; and Mr. Clark informs his readers that, for the purpose of finally settling and disposing of the question of curved *versus* straight blades, he made several observations and experiments upon the two pumps exhibited. We cannot now enter into the details of Mr. Clark's observations, but he concludes that the useful work done by the Appold pump, exhibited by Messrs. Easton, Amos, and Sons, amounted to $73\frac{3}{4}$ per cent. of the indicator power of the engine, whilst that of Messrs. Gwynne and Co.'s pump did not, on a liberal estimate, exceed $53\frac{1}{2}$ per cent. of the indicator power. The low efficiency of Gwynne's pump is probably what one would anticipate from the large excess of the power actually consumed by it ($185\frac{1}{2}$ indicator horse-power) over the power which Mr. Clark states was originally applied for by the exhibitors, which was only 85 indicator horse-power.

But we come to a very serviceable and efficient form of pump for general purposes—the chain-pump, exhibited by Mr. Middleton—now extensively employed on the Main Drainage Works. According to the results of observations taken under Mr. Lovick's directions for the Metropolitan Board of Works, the slip averaged 20 per cent. of the speed of the lifts, and the useful work done averaged 63 per cent. of the indicator horse-power of the engine, lifting the water 60 feet high. There can be no doubt that for high lifts some form of chain-pump is decidedly better adapted than any form of centrifugal pump.

Siemen's ingenious and efficient gas furnaces, steam cranes, steam-steering apparatus, frictional gear, differential pully blocks, hydraulic lifting jacks, Sissons and White's steam pile driver, diving apparatus, washing machines, and many other kinds of machines, are ably and fully described, and passed in review.

The work is illustrated by 431 woodcuts and 39 plate engravings, which, without pandering to a gross craving for detail, clearly exhibit the characteristic features of the machinery. We must not overlook the most elaborate plan of the Western Annex, which must be interesting to all who were associated with the machinery. An elaborate table of contents and a minute and comprehensive index add very much to the value of the work, which, we must further remark, is handsomely got up, and does justice, by its external appearance, to the labours of the author. The volume is indispensable to engineers, and we anticipate a cordial reception by the public.

The Design and Construction of Harbours. By Thos. Stevenson, F.R.S.E. Edinburgh: Adam and Chas. Black. 1864.

In reprinting the article "Harbours" in the last edition of the "Encyclopœdia Britannica," the author has made many additions thereto; and

* For an experimental investigation of this important subject, see the author's work on Railway Machinery, pages 157 and 158.

the work in its present convenient form will be a most valuable addition to the engineers' library.

The chapters devoted to "Generation of Waves" and to "Force of Waves" are admirable treatises.

The large amount of practical information which Mr. Stevenson has brought together relative to designing harbours under various circumstances and conditions; and as to the materials and kinds of masonry employed and to be employed in such constructions, together with the useful collection of observed facts and data, given under the general head of "Miscellaneous subjects," successfully realises the aim of the author in making the volume a useful contribution to marine engineeering.

An Elementary Treatise on Orthographic Projection, and Isometrical Drawing designed for Schools, Members of Science classes, &c. By W. S. BINNS, M.C.P., author of "A Course of Geometrical Drawing." London: Longman, Green, Longman, Roberts and Green. 1864.

A very useful elementary treatise. We have noticed approvingly the previously published works of Mr. Binns, and the present elementary treatise equally deserves commendation.

Analysis of Evidence before the Sheffield Jury on the cause of the Failure of the Bradfield Reservoir. By WILLIAM NAYLOR. London: Waterlow and Sons.

This pamphlet, which is entitled an "Analysis of Evidence," reproduces a considerable portion of the evidence given by Messrs. Leather, Gunson, Jackson, Rawlinson, and Beardmore; but instead of analysing any portion of the same, it merely criticises that part of Mr. Rawlinson's evidence in which he condemns the structure of the embankment on account of its porousness. Such evidence, undoubtedly, is open to criticism, especially by those who have successfully carried out similar works; and had Mr. Naylor adduced certain facts as precedents, and taken them as the groundwork of his criticism, less fault might have been found. As it is, however, he has reduced it to a series of quibblings and carpings; and any earnest man who has read Mr. Rawlinson's very sober evidence, must conclude that he has laid himself open to criticism, because he is not so expert a debater as the Chancellor of the Exchequer.

If Mr. Naylor is an engineer, and places the two sentences together in which occur the words which form the subject of his quibble, he will, if at all he is of a mind to do so, easily understand the meaning which they are intended to convey; that meaning, we think, can be only as follows:—

"Inasmuch as the inner half of the embankment was so porous that, under a certain head, the pressure of the volume of water on the puddle wall must have been very considerable, and inasmuch also as the outer half of the embankment offered an uneven surface for the puddle wall to rest against, being chiefly made of rubble, the pressure at some point not known would (or might) be sufficient to crack the puddle wall and thus lead to the catastrophe."

Without further commentary on the evidence—after having vainly endeavoured to ridicule Mr. Rawlinson, who seems to be particularly obnoxious to Mr. Naylor because he was a Government Commissioner—Mr. Naylor proceeds to give his own opinion of the cause of the accident, and jumps at once to the conclusion that it could be nothing but a landslip, because the ground and walls of a cottage were found to be cracked after the occurrence, at a distance of some 350 yards from the breach in the embankment, and his argument in support of that opinion is that this crack "clearly shows that the strata under the cottage and under the seat of the embankment are connected."

Now, it is difficult to conceive how the "strata" (if such a term can be used) upon which a hill side and its valley rests could be otherwise but connected unless some mining operations had been carried on there; but if at all they were disconnected, that is, if there was a gap between them, this would give reasonable ground for conjecture that a slip, or a digression, would or might take place. Had Mr. Naylor walked up the road from Sheffield to the embankment, and carefully observed as he went, he would have seen that about a mile and a quarter below its site beyond the branch valley, in which the Ayden reservoir is being formed, and on the same side as the cottage to which he refers, the ground was considerably cracked at as great a distance from the track of the flood as the cottage; and unless he would ascribe those crackings to a distinct landslip rather than to the flood, he must (reasoning by analogy) ascribe the cracks near the cottage to the effects of the flood also.

Mr. Naylor does not offer to explain where the "strata" (which he maintains have slipped) have shifted to; he furnishes, however, evidence sufficient to show that even where a depression of the ground does take place, no serious consequences need follow, since he states in a foot-note that, in the South Staffordshire district, the bottoms of some canals have sunk owing to the removal of the thick seam coal without injuring the puddle by which underneath they are (together with the sides) made watertight.

Mr. Naylor in his opening paragraph craves the indulgence of the scientific reader, and of the public, for bringing the subject before them, but we fear he cannot be pardoned for giving to his pamphlet so erroneous a title; and covering as it does, not an "Analysis of Evidence," but *ex parte*, and, not only to our mind, erroneous views, but an unwarranted attack upon the very fair and proper evidence of Mr. Rawlinson.

BOOKS RECEIVED.

"Report addressed to the Council of the Society of Arts by the Special Committee on the Statistics of Dwellings Improvements in the Metropolis."

"The Art Workman's Position." A lecture delivered on behalf of the Architectural Museum at the South Kensington Museum, March 16th, 1864. By A. J. BERESFORD HOPE, Esq. London: John Murray, Albemarle-street. 1864.

CORRESPONDENCE.

We cannot hold ourselves responsible for the opinions of our Correspondents

CHAIN CABLE TESTING.

To the Editor of THE ARTIZAN.

SIR,—The "Journal of the Society of Arts" for May 6th contains a report of an elaborate and valuable paper by F. A. Paget, Esq., C.E., on the above subject.* There is much useful information in the paper, though I do not agree with every part of it; but, with reference to the question of *adjusting the weights,* I believe it is the usual practice to do this by measuring the sectional area of the indicator valve, and weighting it by a set of levers and small representative weights, so that every pound (say) placed in the scale is the measure of a ton strain on the cable. About fourteen months ago, two gentlemen (of whom the writer was not one), each acting in perfect good faith, both measured the diameter of the indicator valve of a small hydrostatic press, and calculated the area thereby. But one made the area only 2 square inches, whilst the other made it 2,485 square inches, being a difference of more than 24 per cent., all caused by a trifling difference in measuring the diameter. Hence it follows that if each of these gentlemen had prepared a set of weights according to his own calculation, one set would have been each 24 per cent. heavier than the other. This is very vague and unsatisfactory. Another gentleman (not the writer) brought two cylindrical iron bars of different diameters of S C Crown iron, of which the strength is known, expecting that when these irons broke he would know the respective strains which the press was exerting. But, unfortunately, in order to connect these bars with the press it was absolutely necessary to turn an "eye" at each end of each bar to enable the hooks of the press to take hold of them. To do this, each end had to be heated to a welding heat, which of course altered the temper of the metal, and the bars both broke where they had been reheated, and the experiments proved nothing. There is another point which I fear has very seldom been taken into consideration, which, however, applies only to the first ton. In order entirely to prevent the escape of the compressed water, a packing of greased leather is very properly fitted on to the ram, so as exactly to fill the sectional area of the cylinder. The friction of this packing is considerable. In one case I have been credibly informed that it amounted to 11cwt., so that the hydrostatic pressure must amount to 11cwt. on the indicator valve before the press could begin to act on the cable at all; and it follows that the representative weight for the first ton ought to be $1\frac{11}{20}$lb.

Proposed method of adjusting the weights.—Provide a coiled steel spring, say of Bessemer steel, of suitable length and strength with an index affixed, contained in a frame suitable for the purpose, something like an ordinary letter weigher. Hang this up, and place in the scale at the bottom, previously weighed quantities of pig iron. When the total weight so applied is one ton, mark the place pointed at by the index "1 ton." When the total weight applied is 2 tons, mark the place then pointed at by the index as "2 tons," and so forth. The only adjustment required for this machine would be as follows:—When the machine is hung up vertically, the spring itself would depress the index with a force equal to its own weight, whereas when the machine is laid horizontally on the platform, which is the way in which it is intended to be used, the weight of the spring would not depress the index at all. This allowance would not be important; it would probably be less than $\frac{1}{2}$cwt. When this machine was laid on the platform, each end being fastened in the usual manner, there could be "no mistake" about the fact that the press was exerting an exact ton of strain on the cable when the index pointed at "1 ton." And it is equally clear that the press must have also overcome the friction of its leather packing. The first ton representative weight must, therefore, be just so much that the valve would lift it and fly open,

* This will also be found in another portion of our present issue.

when the index pointed at "1 ton;" and so on with the other representative weights.

Actual strength of cables.—This is, according to the experiments at Woolwich, only about two-thirds of the original strength of the rolled bars from which the cables are made. The following is a "Table for ascertaining the strength of the ordinary stud-link chain used in her Majesty's navy from the experiments made at Woolwich Dockyard in 1842-3, computed by Mr. Nicholas Tinmouth, R.N., late Master Attendant." The two first columns are taken from the table; the last two columns have been calculated and added by the present writer.

Diameter of the bar from which the Chain is made. Inches.	Testing Strain adopted. Tons.	Mean Force in Tons per square inch required to break the Chain. Tons.	Proportion of Testing Strain to Breaking Force. Per Cent.
2	72	15·8	70 to 75
$1\frac{7}{8}$	$63\frac{1}{4}$	16·8	64 „ 72
$1\frac{3}{4}$	$55\frac{1}{8}$	15·4	65 „ 85
$1\frac{1}{2}$	$40\frac{1}{2}$	16·8	62 „ 74
$1\frac{1}{8}$	$22\frac{3}{4}$	14·8	69 „ 84
1	18	15·4	66 „ 82
$\frac{7}{8}$	$13\frac{3}{4}$	17·5	61 „ 68
$\frac{3}{4}$	$10\frac{1}{8}$	15·2	67 „ 81
$\frac{5}{8}$	7	15·4	71 „ 75
		Mean 15·9	Means 66 to 77

In four cases the testing strain exceeds 80 per cent. of the breaking force, and the blows with the sledge hammers must be added to this; yet we never hear of any attempts to ascertain how much the permanent set is. If the cables do not break outright or show external signs of damage, the good, the indifferent, and the bad are all certified as having stood the test, which means practically that they are all equally good.

Proposed method of testing.—From each cable to be tested, cut off or cut out 2, 3, or 4 fathoms—which is a small sacrifice to make, in comparison with saving crew, ship, and cargo. And having satisfied yourself that the weights are correct, experiment, with the specimen with 6, 8, 10, 12, 14, 16 tons per square inch up to breaking point. Carefully noting the permanent set with each strain, by means of a vernier, how much per cent. it amounts to of the whole length of the specimen? Now, before we go further, it is necessary to observe, that since every link is exactly like the rest both in size and form, the *tension* undergone by the outside of the link and the *compression* undergone by the inside of the link, will be the same for each link, with the same quality of iron—that is to say, it will be a constant quantity, and so far as bending the iron is concerned, each link would be of equal strength to all the rest; but the loss of strength by welding is a variable quantity. Mr. Paget, quoting Mr. Kirkaldy, says there "was a loss of ultimate breaking strength, averaging from 26 to 43 per cent., the mean being nearly 20 per cent.," the cast iron studs being of equal size and shape, are, also, a constant quantity. To proceed with the account of our proposed method of testing, by breaking the specimen with a known weight, we have, at all events, "done something." For example, a specimen of the identical cable, which is being tested, selected, at the discretion of the superintendent, broke with tons, cwts., qrs., lbs. Now, the long scarfs, where the welding is bad, that is to say, where they are not thoroughly incorporated with each other, will tend to draw asunder and establish a set. And we may reasonably conclude that the more imperfect the welding the greater the permanent set with a given strain. I would, therefore, propose to test the remaining parts of the cable, with, say, 6, 8, and 10 tons per square inch. If the results should give the same permanent sets per cent. of the length of the piece of cable being tested, as were obtained from the specimen, I should conclude that the breaking weight would be same. If the sets were less or more, I should conclude that the breaking weights would be less or more in proportion. This would not injure the cable.

About the blows with hammers, when the cable is under the dead pull of the press.—I do not anticipate any difficulty in proving to the satisfaction of all impartial readers, that this system is most objectionable, and ought at once to be abandoned. In the first place, I totally dissent from the proposition, that "the hammer-test approaches nearer than any other to the kind of work that will have to be done by the cable when at sea." On the contrary, they are as different as possible, and I hold with Capt. Selwyn, R.N., who well remarked in the course of the discussion: "With respect to the tension brought on chains, the chairman (Admiral Sir Edward Belcher) would agree with him, that usually the amount of cable out was so great that the last few fathoms next the anchor lay on the bottom, and so the full force of the strain was never felt. There was, in fact, a spring-like action, so that no sudden impulsive strain was put upon the cable." Exactly so. The cable has no such severe test to undergo when in use, as the blows with the hammers when it is drawn up as tight as a bow-string. When a ship is swinging at anchor, even in a short chopping sea, when lurching in one direction, she merely draws up her cable and diminishes the amount of the catenary curve for the moment; when she lurches in the opposite direction, she increases the catenary curve for the moment. One of the worst features of the hammer test is, that no one knows what is the amount in tons of the test he is applying—he is all abroad, and knows not what he is doing. Even with the different sized hammers for different sized chains, so far as appears, no one even attempts to ascertain what is the amount of force applied. Even if it be admitted (which is conceding a good deal) that the same man can strike a blow of exactly the same number of lbs. every day for years, with a given size of hammer, how can any man contend that a man in Liverpool, and a man in London, will always strike with an exactly equal force, with each a hammer of the same size? One man will be more athletic than the other, and will strike a heavier blow with the same ease to himself as the weaker man does while striking a lighter blow. Thus a more severe strain is applied at one testing-house than at another; but the worst feature of all in the hammer system is this. To the very best cables, no injury, perhaps, is done worth regarding. With the second class, more or less injury will be done to them in proportion to the greater or less imperfection of the welding. Whilst with the very worst, so much injury is done to them, that probably a storm or two would cause them to part. Surely, in common prudence, the effect of the tests in permanent set, ought to be ascertained.

There is good reason to believe, and I rejoice at it on public grounds, that in due time the necessary steps will be taken to ensure a proper adjustment of weights at all testing machines; and also that a less vague and more satisfactory system of testing the chains themselves, will be established.

Jersey, May, 1864. R. A. Peacock.

P.S. The problem to be solved in the first instance, is clearly this: To find out if you can, *without weakening the cable*, how many tons will break it?

NOTICES TO CORRESPONDENTS.

J. P.—1st. The number of revolutions in every steam engine, whether land or marine, will be optional within certain limits. We may take, however, the following example:—Given the area of piston a, the pressure p, the length of stroke l, and the number of revolutions n, the power of the engine will be determined by the following formula:—

$$\text{H.P.} = \frac{a \times p \times 2\,l \times n}{33000}$$

hence,

$$n = \frac{33000\ \text{H. P.}}{2\,a\,p\,l}$$

Thus you will see the horse-power must be given, as being an element to be included in the formula, in order to determine the number of revolutions, and the data you have sent do not include this. 2nd. Your second query is not put sufficiently clear to enable us to comprehend what you really require. If you will state more distinctly what are the points upon which you wish to be informed, we shall be happy to reply to you.

S. R.—The term Registration is used in connection with novel *designs*—useful or ornamental—but does not apply in the case of *inventions* for which *letters patent* are sought. The registration of a design, and the protection of an invention by letters patent, being two separate processes necessitating a different course of procedure for each. The information you seek is, however, more properly within the province of a patent solicitor to reply to you upon. We have, therefore, referred your communication to The Artizan Patent Office. Send your address.

RECENT LEGAL DECISIONS

AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

Under this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

Roberts and another v. Rose.—This was an action tried in the Court of Exchequer, for obstructing a watercourse, and thereby flooding the mines of the plaintiffs. The defendant denied the right of the plaintiffs to the watercourse, inasmuch as the right to use it had been revoked. The plaintiffs alleged that the licence continued until the time of the obstruction, and also that the defendant caused unnecessary damage to

them by the mode of obstruction which he had adopted. The action was tried before Mr. Justice Keating and a special jury, when the following facts were proved:—The plaintiffs were owners of "The Bauk" Colliery, near Darlaston, in Staffordshire, and the defendant was lessee (under Sir Horace St. Paul) of an adjoining mine called "Broadwaters Colliery." In 1860 Sir Horace St. Paul and his tenant of the surface of "Broadwaters" gave the plaintiffs leave to carry off the water pumped up from their mines by means of a watercourse along the Broadwaters land, which they accordingly did until its obstruction by the defendant. In 1861, however, Sir Horace St. Paul let the mines under Broadwaters and the "spoil banks" thereon to the defendant, who afterwards required the plaintiffs to discontinue the pumping of the water along the course, and on their refusing to do so, he went upon a neighbour's land and stopped up the channel, whereby the water was thrown back upon the plaintiff's colliery, and caused them considerable damage. Upon these facts the defendant contended that the lease to him in 1861 operated as a revocation of the licence given by Sir Horace to the plaintiffs to use the watercourse in question, and that the defendant was entitled to require the discontinuance of it. The learned Judge at the trial was of this opinion, but left the question to the jury, whether the defendant had stopped the watercourse in a reasonable manner. The jury found that he had not, and assessed damages contingently at the sum of 165*l*. Cross rules were obtained to enter the verdict for the plaintiffs or defendant. The case has been before the Court upon two or three occasions, and on this occasion arguments terminated. Their Lordships having considered the matter, gave judgment unanimously for the defendant, on the grounds that the lease to him did revoke the licence granted by Sir Horace to the plaintiffs, and that the defendant was justified in going on another's and to stop the flow of the water, as he could not otherwise have stopped it without doing injury to others in the immediate neighbourhood over whose lands the water would have flowed.

TROTMAN *v.* WOOD.—This was an action tried in the Court of Common Pleas, before the Chief Justice, for the infringement of the plaintiff's patent anchor, in which a verdict was found for the plaintiff. A rule having been obtained to set aside the verdict, and to enter it for the defendant, or for a new trial on the ground of misdirection. The patent appeared chiefly to consist in turning the palm, or holding part of the anchor outwards, instead of inwards, and was intended to be applied to Porter's anchors, which have a movable axle at the junction of the arms. The effect of turning the palm outwards was to give these anchors a different angle to the holding part, and make it bite downwards into the ground more firmly. It was contended in support of the rule that the old Dutch form of anchor was with the palm outwards, and that the defendant, in copying that form, had not infringed the plaintiff's patent. Mr. Justice Willes was of opinion that the rule ought to be discharged. The defendant's anchor was unquestionably an infringement of the plaintiff's alleged invention, which was to have the palm outside the arm and the arm moving on its axis. The Lord Chief Justice was not dissatisfied with the verdict: therefore, neither on the ground of law or fact ought the rule to be made absolute. Mr. Justice Byles and the Chief Justice concurred. Rule discharged.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

LONDON MAIN DRAINAGE.—At a recent meeting of the Metropolitan Board of Works, the engineer (Mr. Bazalgette) reported that, at the present time, about one-sixth of the metropolitan sewage was intercepted by the Northern Outfall Sewer Works, and discharged into the Thames at ebb tide at Barking, whence it was carried to the sea. This sewage, about 14,000,000 gallons in quantity, was formerly discharged into the river within the metropolis at low water. The progress made with the Main Drainage Works was thus stated:—On the Main Drainage Middle Level Sewer, work to the amount of £306,000 had been done; on the Western Sewers, 3¾ miles of sewer had been constructed at the cost of £51,000; at the Northern Outfall Reservoir, works had been executed to the estimated cost of £163,000; at the Southern Low Level Sewer 3¾ miles of work had been completed at the cost of £110,000; at the Southern Outfall Works at Crossness, work to the amount of £213,000 had been finished. With respect to the Northern Thames Embankment, the engineer reported that the works of the first contract (from Westminster-bridge to the east side of Cannon-street) had been much delayed by the difficulty in obtaining possession of the wharfs on the side of the river, and by the necessity there was for making experiments as the best form of iron caissons for excluding the tide. Works had been done on this contract to the amount of £30,000, and on the second contract (between Waterloo-bridge and the eastern side of Temple-gardens) to the value of £12,000.

NEW PATENT DIRECT-ACTING STEAM-HOIST.—A new machine, for the purpose of raising weights, driving piles, and general hoisting purposes, has been tried at the works of Messrs. Peters, Brothers, Portwood. This machine is the invention of Mr. A. B. Brown, C.E., of the firm of Scott, Burn, Brown and Co., of London. Most of the ordinary loss of power is avoided, the only wearing parts being reduced to a piston and piston-rod. Steam is admitted from a small tubular boiler, into the cylinder at a high pressure, and is thus permitted to exert its expansive force directly upon the rope by which the weight is raised. The whole machine is portable, and upon wheels. In one of the trial experiments, weight, being at once freed from all resistance, fell at the natural velocity, and descended like a blow from a hammer. The weight lifted was 5 cwt., the speed 900ft. per minute, the indicated pressure of steam 70lb. to the square inch. Eleven blows per minute upon a pile were represented; and it is the opinion of the inventor and constructors that, with a larger steam-producing surface, a speed of from eighteen to nineteen blows could be obtained. The concluding part of the trial was to display its power as to display its power as a general hoist for warehouses, wharfs, mills, and other manufactories. The operation of the machine itself is reported as almost without noise.

IMPROVED CAST-IRON.—*Galignani* states, that cast-iron, composed of old and new metal, in certain proportions, calculated to give it a great power of resistance, acquires a new degree of strength by an addition of 2 per cent. of wolfram, or tungsten. In one of these combinations the increase of the power of resistance to fracture per square centimetre was 44 kilogrammes with French wolfram. In another, formed of one-third of old English cast-iron and two-thirds of old ordnance, the increase, with German wolfram, was 67 kilogrammes per square centimetre. M. Leguen has recently shown that, subjected to a second fusion, cast-iron containing wolfram is still superior to other cast-iron similarly treated. After this operation, the difference of resistance in favour of the former was 26 kilogrammes per square centimetre; and German wolfram is superior to French, even after a second fusion. A third fusion of the same cast-iron having been directly effected in a Wilkinson's furnace, instead of being done in a crucible, as in the preceding cases, the tenacity of wolframed cast-iron was again greater than that of the common sort treated in the same manner. Hence it may be concluded that the action of wolfram subsists even when the fusion is effected directly in a furnace, and remains after several successive fusions. The wolframed cast-iron mentioned above, containing fragments of old ordnance, seems to become stronger at every successive fusion. Another proof of the superiority of wolframed cast-iron over the common sort is that bars made out of the former do not bend so much as the others under the action of equal weights, whence it may be inferred that the wolframed sort is more elastic, and more capable of resistance. In all cases, therefore, in which it is required to have cast-iron offering great resistance to fracture, the addition of a small quantity of wolfram offers an easy means of obtaining it. The wolfram must be pulverised, but need not be reduced. French wolfram must, moreover, be roasted, in order to drive off the sulphur and arsenic it contains; but German, being purer, need only be reduced to powder.

THE TAVISTOCK IRONWORKS AND STEEL ORDNANCE COMPANY, with a capital of 200,000*l*., in shares of 20*l*. each, has been formed for the purchase and carrying on of the business of Messrs. Gill and Co., of Tavistock. The property consists of about 13 acres of land held under a long lease, with the necessary buildings, workmen's cottages, manager's house, &c. There is a never-failing water-power, and the premises are easily accessible by canal from Plymouth Sound, and by railway from all other parts of the kingdom. The purchase includes premises, machinery, plant, stock in trade, patent rights, and goodwill, as well as an advantageous contract for the extensive manufacture of Crease's tunnelling engines and Blakely's guns. The company propose to carry out on a large scale the manufacture of steel under Bessemer's, or other patents, and to manufacture steel, shot, and shell, as well as all kinds of machinery, and implements for mining, manufacturing, and agricultural purposes.

THE ASHTON VALE IRON COMPANY, with a capital of 150,000*l*., in shares of 25*l*. each, has been formed to acquire and work the Ashton Vale coal and iron ores, and to establish the manufacture of wrought and finished iron in the immediate neighbourhood of Bristol. The local market is very extensive, and the difference in carriage alone, as compared with South Staffordshire, will be equal to a profit of 9*s*. per ton.

THE WORCESTER ENGINE WORKS COMPANY, has been formed with a capital of 300,000*l*. in shares of 10*l*. each. The company's business will resemble that of a rolling stock or waggon company, and arrangements have been made for the purchase of the works, machinery, plant, goodwill, and effects of the firm of Messrs. McKenzie, Clunes, and Holland, of the Vulcan Works, Worcester.

THE NEW ATLANTIC CABLE.—One of the improvements in this cable is in the mode in which the gutta-percha coating is applied. Some time ago Mr. Chatterton discovered and patented a compound that is said to have the property of causing the coatings of gutta percha to adhere firmly, without the injurious use of naptha, so as to form a completely solid core. The wires having been formed into a strand, and six wires being twisted round a central one, they are passed through a vessel containing Chatterton's compound, and are then covered with their first coat of gutta percha. about the eighth of an inch thick. After having been examined by hydraulic pressure and by hand, the core receives another coat of Chatterton's compound, and then another layer of gutta percha; and so on until it has attained the thickness of a little more than half an inch in diameter. It is then covered with ten solid wires drawn from Webster's and Horsfall's homogeneous iron, each capable of sustaining a strain of 1,000lb., at which strain it only stretches 1 per cent. These homogeneous iron wires are surrounded separately with five strands of Manilla yarn, saturated with a preservative compound, the poisonous qualities of which have been found by experiment to prevent its destruction by insects, shell-fish, &c.; and the whole are laid spirally round the core, which latter is padded with ordinary hemp, saturated with preservative mixture. The weight of the cable, when completed, is 35¾ cwt. per mile, when weighed in air; but its specific gravity is said to be so little that it is capable of bearing eleven miles of its length when in water, a strain it is impossible it should ever be put to, the deepest water encountered in laying the old cable being less than 2½ nautical miles. The company have made arrangements by which they can turn out fifty miles per week of the finished cable.

POST-OFFICE SAVINGS BANKS.—The deposits received in 1863 amounted to £2,640,919; the withdrawals were £1,026,207, withdrawals including interest as well as original deposit. The principal and interest due to depositors at the end of 1862 was £1,698,302, and at the end of 1863, £3,376,828, or very nearly double the amount at the beginning of the year. The charges of management and expenses for the year 1863 amounted to £25,500.

IRON ARCHITECTURE.—A limited liability company, with a capital of 500,000*l*., in shares of 25*l*. each, is in course of formation, under the title of the Iron Architectural and Engineering Company, for developing the inventions of Mr. W. Vose Pickett, who proposes to substitute iron for other materials in every description. Mr. Pickett considers that the six primary principles of the system are—1. Canister, or hollow, iron walls, with cast chased or *repoussé* work ornamental surface, as a substitute for the solid wall and ashlared surface used in masonry. 2. Interstitial ornamental form, as a substitute for surface-carved, prominent, or basso-relievo form in masonry. 3. In close connexion with the first, and in contrast with the second principle, is the metallic low relief or intaglio form: this, though involving no invention, constitutes with the second two distinct characters to that of the one principle of relieve form in masonry. 4. As a substitute for the columnar portico, colonnade, and arcade of the ancient system, the metallic offers the suspension portico, the advantages of which are numerous. 5. The angular forms so prevalent in all erections in masonry, may be altogether dispensed with by the introduction of the curves of which metal so readily admits. 6. The sixth primary consists in the application of a coating of some kind, indispensable to iron, such as of glass enamel in colour, offering a cheap process of almost eternal durability.

FALL OF A CHIMNEY.—A tall chimney in course of formation at Friezland, Saddleworth, in Lancashire, and belonging to Messrs. R. & R. Whitehead, of the Royal George Mills, has fallen, killing nine persons and injuring others. The new chimney was to be 50 yards in height, and was being built by Mr. John Jackson, of Grasscroft. About 20 yards of it had been built when one side of its foundations gave way, and it swerved,

but was restored to the perpendicular, and was in further progress when it again gave way, and fell to the ground, destroying several houses, the inmates of which had no warning, although the chimney had been watched, and was seen to settle over before it fell.

Opening of the New Reservoir at Nottingham.—This new structure covers an area of an acre and-a-half, being three times the size of the old one, of which in conformation it is an exact duplicate. There are twelve chambers, large and roomy, and 12ft. in height. The reservoir is in length 220ft., and in width 133ft., and it is calculated that it will hold about two-and-a-half million gallons of water. The walls of the reservoir are built of Mapperley Hill bricks.

Portable Coffer Dam for Cleaning and Examining the Bottoms of Ships.—Capt. McKillop recently drew the attention of the Institution of Naval Architects to a coffer dam, consisting of a flexible iron framing and a covering of india-rubber cloth or leather, which can be passed down a ship's side so as, with the side of the ship, to form a tube from which the water can be pumped out. The vessel can by this means be either examined or cleaned, as a man may be sent down a ladder inside it. If it is merely wanted to remove fouling, the ladder may be left out and the lining of the coffer dam brought nearly close to the ship's side, unslaked lime and other substances being dropped in from the water's edge as the machine goes down. When in position, the machine is moved along the bottom by guide ropes. The slaking of the lime destroys the grass and incrustation. Adhesion between the machine and the ship's side is secured by an inflated tube passing down each side and round the bottom of the machine. The machine may also be used to stop a leak, and may be kept on the leak during the remainder of the voyage without great detriment to speed. It can also be used as a raft.

Exhibition of Building Materials.—An exhibition of all the matters employed in construction, rough and in any stage of preparation, is announced to take place at Olten, in the canton of Soleure, Switzerland, on the 18th of August next. The matter has been taken up warmly by the Swiss authorities, and the railway companies have offered to convey exhibitors, visitors, and materials at half the usual prices.

Fortifications.—An account is presented to Parliament every year, made up to the 31st of March, showing the expenditure upon fortifications since the report made in 1860 by the Royal Commission on the defences of the kingdom. The account presented a year ago showed that the expenditure had then reached £2,041,450; it has now risen to £2,856,610, leaving less than £350,000 to be issued of the £3,200,000 authorised by the Acts of 1860 and 1862, but a further sum of £650,000 was authorised by an Act of last Session. The sum of £883,347 has gone for land, £1,859,037 for works, and the rest for incidental expenses. Of the money expended there has been laid out at Portsmouth £1,059,144, at Plymouth £623,185, at Dover £231,336, at the Medway and Sheerness £192,109, at Portland £186,181, at Pembroke £175,563, at Chatham £127,150, at Gravesend £85,955, at Cork £73,705. Surveys and legal charges have absorbed £55,000; civil staff, travelling, &c., £73,198; experiments and clearance works, £9,082. The funds have been raised by terminable annuities expiring in 1885, paying 3¼ per cent., and such annuities have been created to the amount of £193,129.

Artesian Wells in France.—The works for an artesian well on the Butte-au-Cailles, an eminence in the 13th arrondissement (Boulevard de l'Hospital), have now been in progress since April, 1863, and the first subterranean sheet of water having been reached, a strong iron cylinder, weighing 6,000 kilogrammes, has been let down to support the earth. In order not to deprive the artesian wells of Grenelle and Passy of their supply, the bore is to be continued beyond the first sheet, so as to obtain a supply from a lower one, different from that which the Parisians have already drawn so unmercifully. The diameter of the first section just completed is two metres, it reaches the cretaceous bed and will be lined with masonry. The second section will be much narrower, and will be continued to a depth of about 800 metres. Water was found, in the first instance, at a depth of only 32 metres, through alluvial, plaster, and limestone formations, but it was soon found by trial that to reach the clay stratum, the bore must be continued 4 metres 20 centimetres further. This work, however, impeded by the influx of water from all sides, to obviate which a powerful pump of 6-horse steam power was employed; but this having lowered the level of the water by half a metre, the engineers MM. Belgrand and Couche, had to sink a subsidiary well at 4½ metres from the principal one, and establish an additional pump there. At the same time a tunnel 300 metres in length, was constructed to carry off the water. This tunnel, which has been pierced through certain old quarries, is of itself a remarkable piece of engineering. These accessory works being completed, the two pumps being set in motion by two steam engines of 6 horse-power each, were found to yield 1,300,000 litres of water per twenty-four hours; and yet, after a twelve days' labour the level of the water had only fallen one metre; a a third pump had then to be added, and these worked incessantly day and night from the 3rd to the 25th of March last. The labourers, sometimes up to their waists in water, succeeded in piercing through three metres of chlorite limestone, which could only be attacked with steel wedges and enormous sledge hammers. At present all difficulties appear to have been effectually overcome.

The Pneumatic Despatch Company proposed to carry their tunnel through Holborn and Skinner-street to the General Post-office from Euston-square, and with that view they asked the permission of the authorities of Christ's Hospital to carry it below the precincts of the hospital to avoid the great public inconvenience which would be caused by excavation through Newgate-street. The result has been that the governors of the hospital have entirely refused to allow any such work to be undertaken within their property. The Pneumatic Despatch Company have a bill now passed through Parliament by which they propose to obtain compulsory power to effect their object of passing through the hospital, but they have met with such strong and decided opposition from the governors that they have withdrawn from the bill the clauses which were meant to confer such compulsory powers.

Application of Steam Power to Agriculture.—At the last monthly meeting of the Over Agricultural Society, Mr. Henry Nield, of the Grange, Worseley, read a paper on the application of steam power to agriculture. After some interesting remarks, in the course of which he referred to extensive business which was being done in steam machinery, through the agency of the farmers' associations established under the Limited Liability Act, Mr. Nield pointed out the advantage of steam cultivation, as compared with the system generally in use. "The advantage," he said, "of having land, deeply stirred, almost regardless of weather—no horses treading it—with what farmers in general have to contend, in this uncertain climate, must be apparent to the most sceptical. I have witnessed about seven acres of varying character of land, very uneven in hill and dale, most effectively ploughed eight to nine inches deep by the steam plough, during the hours of an ordinary working day. You cannot imagine how rain can percolate, sun and frost act on soil so stirred, in autumn, as a preparation for root-crop cultivation in spring, by a comparison with what most of us less favoured farmers have to put up with; but if we trace the subject of steam cultivation, it leads to our land being brought into proper order for the application of all other improvement and labour—saving implements and machines that agricultural progress is developing." He urged, in short, that ploughing by steam was as much superior to the old system as travelling by railway is to travelling by stage-coach.

The National Gallery.—An estimate has been presented to Parliament proposing a vote of £10,000, the first instalment of £152,000, which is the estimated cost of building a new National Gallery at Burlington House, including finishings and decoration. In forwarding the estimate, the First Commissioner of Works makes the following statement:—"The accompanying estimate is for the erection of the National Gallery on the site purchased by the Government in Piccadilly. The site consists of about 3½ acres, of which one-half is occupied by Burlington House, with its two wings and its colonnade, and by the Royal Society, the University of London, the Linnæan Society, and the Chemical Society; and the large hall is used for the meetings of the Geographical and other learned societies. These buildings need not be disturbed at present, since the garden, which occupies half of the site, will furnish ample accommodation for the pictures, ancient and modern, belonging to the trustees of the National Gallery, and also for the additions to the collections which may be expected by gift and purchase for many years to come. Whenever, however, a large increase of space may be required, Burlington House and its wings will be pulled down to make room for an extension of the National Gallery, and in the meantime the courtyard will make a handsome and convenient approach to the main entrance of the new building, which will be through the central hall of Burlington House. The proposed building will be 300ft. long and 218ft. wide. That part of it which will be devoted to the exhibition of pictures will be of one storey, lit from the ceiling, and will provide 3,000 lineal feet of wall space in a horizontal line, exclusive of doorways, and 36,200 superficial feet of floor space. The larger galleries will be 40ft. wide and 40ft. high, and the rooms for small pictures will be 21ft. wide with a proportionate height. The only external elevation that will be visible will be at the northern side in Burlington Gardens, where the board room and offices of the trustees and the residence of the keeper will be placed in two storeys, and where there will be a public entrance. On the southern side, where the level of the ground is lower, there will be a useful basement storey, and the whole building will be of fire proof construction."

Liverpool Melbourne and Oriental Navigation Co.—A prospectus of the above-named company, has been issued with a capital of £2,000,000, three-fourths to be first subscribed, in shares of £50. The object is to extend the facilities for emigration to Australia, and the company will have at their disposal the existing contract with the Government of the colony of Victoria. The board of direction comprises representatives of the firms of Gibbs, Bright, and Co., James Baines, and Co., and others largely interested in the trade of Liverpool.

Channel Steamship Company.—A prospectus has been issued of the Channel Steamship Company with a capital of £250,000, in shares of £25. The company propose to take over the steam vessels of Mr. H. P. Maples, who has established the line now trading to St. Malo and the Channel Islands.

NAVAL ENGINEERING.

Trial of the "Caledonia."—The iron-cased screw steam frigate *Caledonia*, 35 guns, tested the working capabilities of her machinery previous to the official trial at the measured mile, on the 5th ult. The *Caladonia* is a timber-framed vessel, built at Woolwich Dockyard, and, like her sister ships *Prince Consort*, *Ocean*, and *Royal Oak*, is cased in rolled iron-armour plates 4½in. thick, extending from stem to stern and gunwale to 5ft. below water-line, the ship's sides being filled in solid and strengthened with iron, to enable them to carry this heavy armour, which is secured with through bolts having large washers and nuts on the inside. The upper deck is constructed of iron beams of the *Butterly* type, upon which ⅜in. plates are rivetted, which gives great strength to this part of the ship. The whole of the work of the ship has been performed in a Government dockyard. The machinery is supplied by the firm of Messrs. Maudsley, Son, and Field, of London, and consists of a pair of horizontal double piston rod engines which work the screw shaft direct. Each engine has the whole of its starting and regulating levers grouped together within convenient reach of the engineers. The massive shaft which passes through the stern tube carries the propeller fixed upon it, thus doing away with the well and hoisting apparatus which spoil so many of our noble ships and cramp their steering apparatus. The propeller, has four blades, variable in pitch from 20ft. to 25ft., and is 20in. long on line of keel, with a diameter of 21ft. The screw can be disconnected from the engines when the ship is under sail by withdrawing the coupling bolts and allowing the after length of shaft and propeller to turn round. The vessel is fitted with two auxiliary engines for feeding the boilers; there are also two others for extinguishing fire and pumping out the ship. Two steam crabs are also fixed on deck for the purpose of raising ashes and for general purposes. During the trial the *Caledonia* had a draught of water forward 22ft. 4in., and aft 23ft. 11in. She had on board 245 tons of coal, 200 tons of cables, stores, &c., and about 100 tons of water, crew, &c. Her guns and ordnance stores have not yet been put on board. Six runs were made at full boiler-power on the measured mile with the following results:—First run—time, 5min. 24sec.; speed 11·111 knots; revolutions of engine, 58; pressure of steam, 20; vacuum, 26. Second run—time, 3min. 58 secs.; speed, 15·126 knots; revolutions of engines, 57; pressure of steam, 19; vacuum, 26. Third run—time 5min. 31sec.; speed, 10·876 knots; revolutions of engines, 58; pressure of steam, 19; vacuum, 26. Fourth run—time, 3min. 57sec.; speed, 15·190 knots; revolutions of engines, 57; pressure of steam, 19; vacuum, 26. Fifth run—time, 5min. 40 sec.; speed, 10·588 knots; revolutions of engines, 56; pressure of steam, 16·5; vacuum, 25·5. Sixth run—time, 4min. 40sec.; speed, 14·516 knots; revolutions of engines, 56; pressure of steam, 16·5; vacuum, 25·5, giving as a first means 13·118, 13·001, 13·033, 12·889, and 12·552 knots; and the second means, 13·059 13.017, 12·961, and 12·720 knots, the true mean being 12·939 knots per hour.

Testing of Rodger's Anchor.—By order of the Lords Commissioners of the Admiralty a number of Captain Rodger's indented small-palmed anchors and kedges, manufactured by the North Field Iron and Steel Works Company, at Rotherham, in Yorkshire, have been tested by means of the hydraulic machinery in Woolwich dockyard. The anchors varied in weight and denomination, from those capable of holding a ship of 600 tons to the simple pickaxe kedge weighing 5cwt. 20lb., used for boat service. The testing commenced at 10 a.m., and was continued throughout the day. The first application of the proof was with an anchor weighing 11cwt. 26lb., and the machinery was worked up to a tensile strain of 21 13-16 tons, which produced a deflection of 3-16ths of an inch. On removing the strain the anchor recovered its orginal form, without injury. This constituted the complete test required by the Admiralty regulations. Captain Rodger, being desirous of demonstrating its powers of resistance to an extraordinary degree, suggested that the strain should be increased. It was then tried at a strain of 84 tons, and gave a 6-16 deflection; at 36 tons, ⅜; and at 37½, 3-16. This was exceedingly satisfactory. On loosening the strain, after each test, a measurement of the anchor was made, by which it was proved that the form was totally unchanged. It was then turned over, and the other arm was subjected to a precisely similar test with equal success. The other anchors underwent the ordinary proof, which was considered ample and satisfactory. These anchors are recently made upon an improved principle as regards the crown, the arms, and the palms. The additional strength is obtained partly by making the arms shorter than is usual in proportion to the length of the shank, and partly by their sectional form. The increased holding power given by the peculiar form of the arm is evinced when the anchor is dragged, as it then forces the ground out laterally without disturbing it in front in the slightest degree. The stream and kedge anchors are on the same principle as the bower anchors, but, as they do not require equal strength, they are considerably longer, and for the convenience of carrying them out in boats they are made without palms.

Testing Hydraulic Machines.—The operation of testing one of the new hydraulic machines, of a size larger than any hitherto in use at either of the Royal dockyards, for bending the armour plates with which the sides of the *Bellerophon* and *Lord Warden* will be be encased, took place at Chatham dockyard on the 19th ult. The machine

tested was manufactured by Messrs. Westwood, Baillie, and Co., Millwall, and was one of the largest ever sent out by that firm. The plates operated upon were four of the 4½in. *Lord Warden* slabs, sent in by Messrs. John Brown, and Co., of the Atlas Works, Sheffield, the plates being of rolled iron. The hydraulic machine was worked by steam power, and within three minutes after the pumps had been set in motion the required curve was given to the plate, which was only slightly heated before being placed in the machine. The contract made by the Admiralty by Messrs. Westwood Baillie and Co. stipulates that the hydraulic machines shall be capable of bending plates of 9in. thickness when chilled, but the machine tested on the 19th ult. is equal to bending plates up to 12in., and even to 14in., should plates of the latter thickness ever require to be operated on.

The Russian Navy.—A large armour-plate steam-ram, of between 3,000 and 4,000 tons, built by an English firm—Messrs. Charles Mitchell and Co., of Low Walker, on the Tyne—will be launched from the Government dockyard, St. Petersburg, this month for the Russian Government. She has been built by English workmen sent out from this country, and her armour-plates have also been manufactured in England. A gun-boat, built by English workmen, will also be launched about the same time.

The "Royal Sovereign" turret-ship was taken out of Portsmouth harbour on the 10th ult. for a preliminary trial of her machinery. She is fitted with three distinct sets of steering apparatus—one on the upper deck, one in the pilot-house forward, and one in the captain's cabin below, and the opportunity was taken of testing their powers on the ship's rudder, under steam, on the vessel reaching Spithead. They all three appeared to answer perfectly, and to have ample command over the rudder in all positions. The ship herself answered her helm very readily, and turned round a circle of small diameter in an unusually short time. In going down Stoke's Bay, the time was taken of one run past the marks, and the ship was found to be going exactly 12 knots. Had she been prepared for the mile in the usual manner there can be no doubt she would have made 13 knots. Her draught of water was 20ft. 11in. forward, and 24ft. aft. She had her guns, shot, and coals on board. On her light draught trial in Stoke's Bay on the 12th of May, 1858, when a three-decker, she realised a mean speed of 12·252 knots, the draught of water being 18ft. 8in. forwards, and 21ft. 9in. aft. The trying of the ship's steering power and the run through Stoke's Bay were all satisfactory.

Armour-plated Vessels.—A return has been prepared at the Admiralty, and presented to Parliament on the motion of Mr. Laird, giving an account of our iron-plated ships and batteries built or building, their armament, horse-power, draught of water, and other particulars concerning them. The return comprises the 16 vessels already afloat and the seven floating batteries; and it includes 11 vessels now building and to be either wholly or partially armour-clad, to be completed at various dates within the next twelve months. Of the ships in the list, the first—the *Warrior*—was launched in December, 1860; the floating batteries are all of the date of 1855 and 1856. The *Black Prince* is the most costly ship in the list, the first cost, including engines and fittings, amounting to £363,813; draught of water aft, 27ft. 3in. The ships entered as "building" are the *Agincourt*, described here as ready for launching, but completing before undocking; the *Prince Albert* and the *Favourite*, marked here for launching this month; the *Royal Alfred*, for October; the *Pallas*, for December; *Bellerophon, Lord Clyde Lord Warden*, and *Vixen*, March, 1865; and the *Northumberland*, April, 1865.

Naval Appointments.—The following appointments have taken place since our last:—J. Petts, Assist.-Engineer, to the *Royal George*; J. Crawford, Assist.-Engineer, to the *Irresistible*; M. Murray, Engineer, to the *Asia*, as supernumerary; H. Duncan, supernumerary, in the *Indus*, promoted to Engineer; E. Daniels, Engineer, to the *Salamis*; J. Frazer, Assist.-Engineer, to the *Himalaya*; W. White and J. Taylor, Assist.Engineer, to the *Salamis*; J. Turner, (B) Engineer, to the *Indus*, for the *Gleaner*; J. Blight, Engineer, to the *Galatea*; H. C. Jones, Engineer, to the *Enterprise*; J. M'Laren, First-class Assist.-Engineer, to the *Salamis*; W. Wallace, First-class Assist.-Engineer, to the *Enterprise*; J. A. Cawley, Second-class Assist.-Engineer, to the *Enterprise*; R. Brown, Chief Engineer, to the *Assurance*; J. C. Grey, T. Fielden, W. Miller, and J. M'Glasham, promoted to Engineers; J. Hindley, T. P. Potts, and E. C. Spencer, promoted to Acting Engineers; R. Blackwood, First-class Assist.-Engineer, to the *Assurance*; V. C. Friend, Second-class Assist.-Engineer, to the *Assurance*; O. M. Browker, Chief Engineer, to the *Cumberland*, as supernumerary; J. P. Lloyd, Engineer, to the *Indus*, for the *Calliope*; W. C. Moreton, Engineer, to the *Indus*, for the *Ripple*; T. F. Hall, Chief Engineer, G. L. D. P. Kelling, Engineer, and J. Smethers, First-class Assist.-Engineer, to the *Wolverene*; E. Holmes and N. H. Rowe, Acting Second-class Assist.-Engineers, to the *Cumberland*; R. Irwin, Acting Second-class Assist.-Engineer, to the *Wolverene*; J. Neil, Chief Engineer, to the *Indus*, for the *St. Jean d'Acre*; W. G. Starling, Second-class Assist.-Engineer, to the *Enterprise*; T. W. Sutton, Chief Engineer, to the *Fisgard*, for the *Prince Albert*; H. Cooper, in the *Rattler*, promoted to be Acting Chief Engineer; G. L. D. P. Keeling, Engineer, to the *Fisgard*, as supernumerary; T. Wilson, Engineer, to the *Wolverene*; J. J. Blunden, Engineer, to the *Asia*; H. W. Masterman, Assist.-Engineer, to the *Fisgard*, as supernumerary; and W.G. M'Burney, Assist.-Engineer, to the *Gladiator*; P. Sumison, Assist.-Engineer, to the *Assurance*; J. Paterson, Chief Engineer, to the *Indus*, for the *Agincourt*; C. R. Chamberlain, Chief Engineer, to the *Cumberland* for the *Ariadne*; J. Morris, promoted to Chief Engineer, and appointed to the *Cumberland* for the *Scout*; W. Tregilgas, Engineer, to the *Asia*, for the *Wallace*; W. M'Intyre, Assist.-Engineer, to the *Cumberland*, as supernumerary; J. Ashley, Chief Engineer, to the *Orontes*, vice Roberts, superseded; F. H. Herrmann, Engineer, to the *Asia*, for hospital treatment; G. Wynhall, Engineer, to the *Orontes*; P. Robertson, of the *Edgar*, confirmed as Engineer; T. Wilmot, of the *Pembroke*, promoted to First-class Assist.-Engineer; and A. G. Roberts, Clerk, to the *Blenheim*. T. P. Reed has been appointed Lieutenant in the Royal Navy Reserve.

MILITARY ENGINEERING.

The Mackay Gun.—On the 9th ult. the Mackay gun was again fired with remarkable results. The target represented a section of the side of the *Agincourt*, and was constructed with a 5½in. armour-plate, 9in. teak backing, ⅝in. iron skin, timber balks, and sand, large piles supporting and strengthening the whole. A steel bolt, weighing 153lb., was fired at 200 yards, and went clean through the target, buried a piece of 90lb. weight 4ft. deep in the sand, and then travelled 440 yards along the beach.

Trial of Guns at Portsmouth.—Two guns which have become known by the distinctive names of the Somerset and the Frederick have undergone at Portsmouth a competitive trial of their armour-plate piercing powers. The two guns are Armstrong guns. The Somerset gun is a coil-built, smooth-bore, has a diameter of bore 9·22in. and weighs 6 tons. The Frederick gun is also coil-built, but is rifled on Sir William Armstrong's shunt principle, has a diameter of bore of 7in. and weighs 6 tons 13cwt. 3qrs. The smooth-bore presents no external difference from others of Sir William Armstrong's muzzle-loading guns, but the shunt gun, from the greater weight and disposition of metal at its breech, assimilates somewhat in form at that part to the American Dahlgren gun. Both guns were mounted on board the *Stork* gunboat, and the plates to be fired at were bolted on the port side of the *America* target-ship, the gunboat and target ship being moored in positions at 200 yards distance in the upper part of Portsmouth harbour. The plates, or rather pieces of plates, that had to be fired at had been specially selected for this trial, on account of their known superior qualities, and from their different methods of manufacture—one being the sound end of a plate that had been previously tested in the ordinary way, and which, now that it was cut off from the main body for the present trial, measured 9ft. 11in. in length by 3ft. 8in. in width, and was 5½in. in thickness. It was of rolled manufacture, from the firm of John Brown and Co., of the Atlas Works Sheffield. The second plate was also the sound end cut off from a plate previously tested. It measured 8ft. 10in. in length by 3ft. 5in. in width, and was also 5½in. in thickness. It was of hammered manufacture, from the works of the Thames Ironworks and Shipbuilding Company. The practice commenced with a steel spherical shot from the 9·22in. gun, fired with a 30-pounder charge of powder at Messrs. Brown's plate, the weight of the shot being 115lb. The shot struck the plate full on its right centre, and partially turned round in the plate and broke up, its broken outer surface being flush with the plate's outer surface. Inside the ship the only visible damage was a piece of the inner planking at the back of the plate, about 9ft. in length, started from the ship and standing out at an angle of about 20 degrees. The shunt gun was next charged with an elongated steel shot weighing 98 pounds and 25lb. of powder, and laid at the same plate. This shot took effect on the plate which allowed of no correct results being arrived at between the two shots and therefore it was determined to send another from the same gun and against the same plate, in order to arrive at definite results. This second shot, by a singular coincidence, struck in the immediate vicinity of the last, their edges overlapping, and consequently the result, so far as related to the object of the trial, was *nil*. The backing of the plate at this end had been destroyed by the previous shot, and the present one striking in the same place passed simply through the shattered side into the ship, and out again through the opposite side. The next shot was a spherical steel, and fired from the smooth-bore with a 30lb. charge, and was directed against the Thames Company's plate. This shot struck upon the lower edge of the plate and within two inches of a bolt. It drove the broken pieces of plate 14in. into the ship's side from the plate's outer surface, extending the fracture through the bolt hole and lower edge of the plate, and destroyed itself in the broken *debris* of the plate. Inboard the inner planking at the back of the plate was started 5ft. in length by 3ft. 6in. in width, and bulging inwards at its greatest part 15in. An elongated steel shot was next sent against the same plate from the shunt gun with a 25lb. charge. and the same unsatisfactory kind of result followed, for the shot again struck on the plate's edge, only this time on the upper edge. It broke the plate into the ship's side 19in. beyond the plate's outer surface, and afterwards passed through into the ship, where it was picked up lying on the deck and but little altered in form, its diameter at the end where it struck the plate having been increased but one inch and eight-tenths, the openings in the metal radiating from the centre of the point of impact being at the same time but very slight. Another steel bolt was then sent at this plate with a 25lb. charge from the shunt gun. On examining the plate after the shot had been fired the base of the latter was found to be standing outwards 5in. from the plate's outer surface, it being thus embedded half its own length in the plate. On inspecting the inside of the ship, it was found the shot had struck immediately upon a knee the fastenings of which had stood firm under the shock of the blow, and hence the non-penetration of the shot. The firing at the two selected plates concluded with a 98lb. steel elongated shell, a new pattern Armstrong, containing a bursting charge of 1lb. 14oz., fired at Brown's plate, from the shunt gun. It struck the plate close to the upper edge, and, bursting by the force of its own blow on the plate, sent up an immense column of smoke in the air, while its broken parts came flying back towards the gunboat. The indent on the plate at the deepest part was only 4in., and although the shell must have exploded at the moment of reaching the deepest part of its indentation into the plate the metal was but insignificantly affected by it. In addition to [the shots fired from the two guns at the selected plates, according to the programme of the day's trial, a steel shot from each gun was fired at a 6-inch plate manufactured at the Millwall Ironworks for the Bellerophon iron frigate, the charge of powder being in each instance of the same amount as had been used in the previous firing. The spherical shot from the smooth-bore gun made a hole in the plate 10½in. in diameter, and drove the broken parts of the plate in 8in. from the plate's outer surface, the shot striking full in a central position on the plate and in front of a knee, and failing to get through into the ship, as much from the resistance offered by the knee as its own weakness, broke up and fell overboard. The elongated shot from the shunt gun also struck fully on the plate, and entering by a hole 8in. in diameter buried itself among the *debris* of the broken plate in the ship's side, with its base, 4½in. in from the plate's outer surface. Inboard, the ship's side was bulged in at the back of the plate.

STEAM SHIPPING.

Iron Shipbuilding at the South Wales Ports.—Messrs. Scott, Russell and Co. have commenced the construction of an iron vessel at their shipbuilding dock at Cardiff, and a large number of skilled hands will shortly be employed. Contracts have been accepted for building several more iron ships, and the same will be commenced immediately the shipbuilding yard is completed. Messrs. Batchelor Brothers and Messrs. Hill and Sons have also iron vessels in course of being built, and this branch of trade promises to become an important one before long at the port of Cardiff. At Llanelly iron shipbuilding has been commenced for some time, and two iron ships have been launched. At Newport, also, the Wood and Iron Shipbuilding Company are effecting extensive alterations at their newly-acquired establishment, with the view of building iron vessels.

The Trial Trip of "Tasmanian."—The Royal Mail Company's screw steamship Tasmanian having completed a thorough overhaul in every department, was taken to Stoke's Bay for an official trial prior to being again placed on the trunk line from Southampton to St. Thomas. Several important alterations and improvements in the internal arrangements of this vessel have been effected, including the addition of a capacious new poop deck. The mean of four runs on the measured mile gave a speed of 13,069 knots, or 15 statute miles per hour; average revolutions, 49; steam, 16lb.; 926 tons of coals and water on board; draught, 19ft. forward and 21ft. 10in. aft. The engines, which are of 700-horse power nominal, indicated 2,200 during the trial.

Steam Shipbuilding on the Clyde.—The *Lusitania*, built seven or eight years since by Messrs. Reid and Co., of Port Glasgow, and engined by Messrs. M'Nab and Co., of Greenock, and which has been running since 1856 between Lisbon and Oporto, has quitted the Clyde, after receiving new boilers, besides being lengthened 30ft. The *Washington*, the first of three steamers built on the Clyde for the Compagnie Générale Transatlantique, has arrived at Havre, having made the run to that port from the Clyde in 50 hours. Her engines worked extremely well. The Compagnie Générale Transatlantique will commence its service between Havre and New York in the present month. The *Lillian* a paddle steamer, recently built by Messrs. Thomson and Co., of Glasgow, for the South American trade, has adjusted her compasses at Gareloch. Messrs. Scott have launched a paddle steamer intended to be a blockade-runner, and the fourth steamer which they have built for a similar purpose. The *Lafayette*, the second of the three steamers which Messrs. Scott are building on the Clyde for the French Compagnie Général Transatlantique, has been receiving her engines at Greenock. The Clyde Shipbuilding Company has launched the *Leven*, a steamer, 140ft, long, 14ft. broad, and 6ft. 10in. deep, for the Dumbarton Steamboat Company, who are organising a fleet intended to trade between Glasgow, Dumbarton, and Greenock. The *Leven* is to be supplied with oscillating engines of 40-horse power, nominal, by Messrs. Blackmore and Rankine. Messrs. C. Connell and Co. have launched the *Eagle*, a paddle steamer built for river passenger traffic, and which is now being engined by Messrs. D. and W. Henderson. The Clyde Shipbuilding Company has launched the *Lennox*, a paddle, and a similar vessel the *Leven*. The same company has launched the *Beatrice* intended for the South American trade, and of the following dimensions:—Length, 190ft.; breadth, 23ft.; depth, 10ft. 3in. The *Beatrice* is now being fitted by Messrs. Henderson and Coulbourn, Renfrew, with engines of 150-horse-power. Messrs. A. and J. Inglis, of Pointhouse, have launched a twin screw of 370 tons, with friction-geared engines of 50-horse power, named *Platypas*. The steamer has been built for the Queensland Steam Navigation Company,

and is the first vessel fitted with a double screw and driven by friction gear built on the Clyde. Messrs. Barclay, Curle, and Co., of Stobcross, have launched an iron screw built for the Carron Company for the Grangemouth and London trade. She is named the *Clutha*, and is being fitted by the builders with engines of 130-horse power. Her dimensions are:—Length, 190ft.; breadth, 27ft. 6in.; and depth, 15ft.; and her burden is 700 tons. The *Roe*, a paddle, built for Messrs. Burns's new fleet of steamers for the mail service between Scotland and Ireland, has "run the lights," on a trial trip, in 51½min.; this is equal to a speed of 15½ miles per hour. The *Iowa*, a screw of 2,200 tons, built in Waterford for the General Steam Navigation Co., is now being engined on the Clyde. The *Ivanhoe*, paddle, lately launched by Messrs. Scott and Co., and intended for the South American trade, has run the measured mile in Gareloch in 3min. 34sec., a speed equal to nearly 19½ miles per hour. Messrs. Caird and Co. have launched a paddle named the *Douglas* for the Isle of Man Steamboat Company; she is a sister vessel to the *Snaefell*, and fitted out by the same firm. The Union Shipbuilding Company has launched from its yard at Kelvinhaugh a screw named the *Prince Cadwgan*, intended for the Aberayron and Bristol trade. Her dimensions are:—Length of keel and fore-rake, 110ft.; beam, 19ft.; depth of hold, 8ft.; burden, 158 tons, builders' measurement. The engines are direct-acting, non-condensing, and of 40-horse power. The same company has launched another small screw named the *Norseman*, intended for the coasting trade, and of the following dimensions:—Length of keel and fore-rake, 83ft.; beam, 18ft. 6in.; and depth of hold, 8ft. 6in. The *Iona*, paddle, has been built by Messrs. J. and G. Thomson, of Govan, for Messrs. D. Hutcheson and Co.'s Ardrishaig line. She is intended to replace the *Iona*, put on the station early in the summer of 1863, but sold in the autumn for blockade-running purposes, and subsequently lost in the British Channel. The new *Iona* closely resembles her predecessor, and is 255ft. in length by 15ft. 6in. beam. She is now being fitted by Messrs. Thomson with engines of 180-horse power. Messrs. Blackwood and Gordon, of Port Glasgow, have launched the *Chancellor*, built for the Arrochar and Glasgow station. She is 170ft. long, 18ft. 6in. broad, and 8ft. depth of hold, and will be propelled by a pair of diagonal engines of 70-horse power, supplied by the builders.

LAUNCHES.

The Launch of the "Prince Albert," from Messrs. Samuda's yard at Poplar, took place on the 23rd ult. The *Prince Albert* is not only ironcased, but has her battery in cupolas, or circular iron turrets. The length of the *Prince Albert* turret-ship over all is 240ft., while her breadth is as much as 48ft., proportions which give her a rather heavy and unweildy appearance. Her depth is no less than 28ft., and her burden, in tons, 2,529. All the details relating to her general principle of construction are almost precisely similar to those adopted in the *Warrior*, the *Black Prince*, and others of our armour ships. The same care is shown to give extra strength by longitudinal bracings; there are the same wing passages along the broadside, which virtually make a double ship of her; she has no external keel, but two bilge plates at each side, which are supposed to answer the same purpose in giving her stability. The plating, too, is the same as on the *Warrior*, 4½in. iron and 18in. of teak, but the *Prince Albert* is plated from end to end, instead of only over the broadside. At the extreme end of the bows and stern, however, the thickness of the armour is diminished gradually to three inches, and instead of going 5ft. below the water-line, as in other armour clads, it is only taken down 4ft.—a slightness of immersion which seems to bring the vulnerable parts dangerously near the surface. Her upper deck is of pine, with a three-quarter inch iron deck beneath it to keep out shells. She is to be furnished with furnaces for heating shot and melting iron, and is to be driven by engines of 500-horse power nominal—an amount of horse-power which certainly seems small when compared with the tonnage or the area of her midships section. The screw is to be four-bladed, and not to lift. On deck are to be four turrets or shields, as they are indifferently called, with an iron plated pilot-house in the bows. Three of the turrets are 22ft. diameter and one of 20ft. The pilot-house is a mere oval about 6ft. wide by 12ft. long, but plated like the turrets, with 5½in. of armour over 7in. of diagonal planking. All these turrets, of course, are moveable, and are revolved on turntables worked from the main deck below. Two of the turrets, it is understood, are to carry two guns each, and two are to carry one each of the heaviest calibre that can be got. All the turrets being placed amidships the bulwarks round the upper deck have to be moveable, and are accordingly made of light iron fastened by hinges to the deck, so as to be capable of being lowered at a moment's notice, leaving the guns free to fire anywhere. The *Prince Albert* was sent afloat with the lower streak of armour on from end to end, and with the midship portion of her broadside entirely plated. The rest of her fitting and equipment will be proceeded with at Woolwich, but nearly, if not quite, a year is likely to elapse before she is commissioned and afloat an effective member of the Channel squadron.

Launch of the Steamer "Evelyn Mary."—On the 24th ult., the above-named steamer for Messrs. Dixon and Harris, of London, was launched from the iron shipbuilding yard of Messrs. J. Wigham Richardson and Co., of Low Walker. The dimensions of the new vessel are—length, 182ft.; beam, 27ft.; depth, 16½ft., with engines by Messrs. Hawthorn of 70 nominal horse-power, and she is fitted with water ballast and in every respect adapted for the coal trade. She will carry about 750 tons cargo.

The "Venitia," screw steamer was recently launched from the building-yard of Messrs. Mitchell and Co., Low Walker. She is built for the London, Italian, and Adriatic Steam Navigation Company, of London, and was launched, fully rigged. She will be fitted with engines by Messrs. Maudslay Sons, and Field. The engines will be of 150-horse power, and on the three-cylinder principle. This vessel is 230ft. long by 29ft. 6in. in breadth, and 16ft. 6in. in depth. Her tonnage is 917. She is sister ship to the *Clotilda*, which was launched last year from the same yard for the same owners.

TELEGRAPHIC ENGINEERING.

A Canadian Telegraph Company.—A new company has been organised in Canada called the Provincial Telegraph Company, with which the United States Company will be connected at Suspension Bridge and at Montreal. One of the most important features of this enterprise is its probable connection with a line to Europe, to which the attention of the public has not been called. This line is from the coast of Labrador, *via* Greenland, Iceland, and the Faroe Isles, to the north shore of Scotland. The longest distance from shore to shore is less than 500 miles—a less distance than cables are now successfully working in the Mediterranean.

RAILWAYS.

London and North-Western.—The line or lines owned by the company are 1,229¾ miles long. Its traffic last year was £4,975,336, and will this year be considerably more than five millions. The traffic increase of the company for the 20 weeks of the current half year, is as much as £174,369. £400,000, at least, is expected to be the London and North-Western's increase in revenue receipts this year. The charges made by the company against revenue are in excess of those which need be made, on the average, in order to work and maintain the line. In the renewal department especially, the company are making extremely heavy present charges against revenue for the benefit of the future. The dividends of the London and North-Western in the three last years have been:—In 1861, £4 5s. per cent.; 1862, £4 12s. 6d.; 1863, £5 2s. 6d.

Eastern of France.—The report states that the total capital of the company to the 31st of December, 1863, amounted in shares to 250,000,000f. (£10,000,000), and in obligations to 548,180,830f. (£21,927,233). The total expenditure to that date was 784,125,486f. (£31,365,019), including 41,325,341f. (£1,653,014) expended in the year 1863, leaving a balance in various securities and reserved fund of 14,055,352f. (£562,214). The traffic receipts, after certain deductions for duty, &c., amounted for the year 1863 on the old lines to 47,327,712f. (£1,893,108), the expense of working to 19,788,482f. (£751,539), the interest on loans to 3,165,254f. (£126,610), and for renewals of the line to 2,154,135f. (£86,165) leaving a balance of 23,222,842f. (£928,914). From this was deducted 1,161,142f. (£46,446), being five per cent. for the reserve fund, and 5,626,022f. (£225,041) for sinking fund of obligations, &c., leaving a net sum of 16,435,678f. (£657,427) for dividend, out of which 20f. per share, or 9,918,820f. (£396,753), were paid to the shareholders in November last, and 6,516,858f. (£260,674) remaining for distribution, or 13f. per share, making 33f. per share or £6 12s. per cent. for the year, leaving a balance of 16,858f. (£674) for the next account.

Bombay, Baroda, and Central Indian Railway.—It has been decided to open this line of railway from Bombay through to Ahmedabad this day for passenger traffic, and immediately after the monsoon for goods traffic.

Railway Axles.—An invention has been provisionally specified by Mr. M. Roberts, of Crickhowell, Brecon, which comprises a mode of permitting each wheel and its axle of the carriage freely to rotate independently of the other wheels and axles, while at the same time, he supports the axles in such a manner as to release them as much as possible from the injurious influence of the of the oscillations of the carriage body. By this arrangement he prevents that wear and strain on the wheels, axles, and surface of the road, which take place under the usual arrangement of railway carriage axles, whenever the wheels differ from each other in diameter, or the line of road is curved, or when the brakes are applied. To obtain this end, while using a separate axle for every wheel—the wheel being fixed to one end thereof, and supporting that end in any suitable manner—he supports the other end of the axle by one or more of the other axles of the carriage, either by a frame, collar, or bearing, or by some other suitable arrangement.

A Railway Across the Andes.—Mr. Henry Meiggs had discovered the existence of a pass called the Valle de las Cinegas, in the Colchagua chain of mountains highly favourable to the construction of a railway to connect the Pacific and Atlantic seaboards of the South American continent. He has presented a report on the subject to the President of the Republic. It appears that the pass in question is placed at an elevation of only 6,000ft. above the central valley of Chili. The proposed railway could be carried out by means of an extensive prolongation of existing lines, or of lines in course of construction. The total cost is estimated at about £1,600,000, and the time necessary for its execution, it is said, would not more than four years. The pass is some eighty-five miles in extent.

The Adhesion of Locomotives.—An improvement upon the ordinary American expedient of making the sand-box a jacket to the steam-dome has been recently patented by Messrs. Proffitt and Duncan, the advantage obtained being that a supply of absolutely dry sand sufficient for the longest journey likely to be performed with a single train is provided; whilst the sand is made very good use of to prevent the radiation of the heat from the body of the boiler—the sand being made, in fact, a steam-jacket, and supplied, when required, by the simple shifting of a valve, through pipes of a suitable form. The quantity of sand thrown upon the rail can be regulated to a nicety, according to the state of the rail or gradient upon which the train is running. Messrs. Proffitt and Duncan state that the preference given to a receptacle round the generator of the locomotive is, that by so doing the sand will be kept in a perfectly dry state, and the action of the atmosphere will have a less condensing effect upon the generator, and the said receptacle may have a partition inserted so as to fill its upper part with charcoal, or other suitable substance, in order to keep the heat more concentrated. The receptacles may be made of iron or other suitable material, and the pipes may be placed both behind and in front of the wheels, so as to produce the same effect whichever way the locomotive or carriage may be proceeding.

London, Chatham, and Dover Railway Extension to Blackfriars.—On the 28th ult., Captain Tyler, R.E., the Government inspector of railways, made his final inspection of the extension line from the Elephant and Castle to Blackfriars Bridge. Locomotives were run backwards and forwards, and every available test applied. The inspection of the line lasted two hours and three-quarters, and at the close Captain Tyler expressed himself, we understand, as being perfectly satisfied, and intimated to the officials his approval of the arrangements; the line will consequently be opened for passenger traffic this day (June 1st). The distance from Blackfriars Station to the Elephant and Castle is about one and a quarter mile.

RAILWAY ACCIDENTS.

Railway Accident at Welwyn Junction.—On the 4th ult., the Hertford branch train left King's-cross at 1.30, and having separated, as usual, at Hatfield, proceeded on its journey. At Welwyn Junction it appears that the points had to be changed to allow of the passage of the train to Hertford, and as far as could be ascertained the signalman held them properly for a time, but not long enough. The train consisted of an engine, tender, and three carriages and had passed the junction points in safety; but before the last carriage containing about 30 persons, had reached the spot the lever by which the points of metal are directed was released. The last portion of the train became separated, and the consequence was that one of the carriages was upset, and several persons were seriously injured.

Explosion of an Engine on the Underground Railway.—On the morning of the 9th ult., about five minute past nine o'clock, an engine exploded at the Bishop's Road station of the Metropolitan (Underground) Railway. It had just come into the station and been attached to the 9.15 train, which was standing at the up platform ready to start. The 9 p.m. train having only a few minutes preceded it, there were few people on the platform at the moment. Both the driver and stoker were on the engine when the accident took place. The boiler exploded in an upwards direction, with such force that the dome, which weighed upwards of 6cwt., was thrown up almost perpendicularly to an immense height. It descended nearly 200 yards from the station, on the further side of the bridge which crosses the Grand Junction Canal. As soon as the steam had somewhat cleared away, it was discovered that a considerable portion of the roof of the station had been blown away; plate glass windows on both sides of the station of nearly half an inch in thickness, as well as those of the carriages, were smashed to atoms, and a portion of the temporary bridge for crossing the station from the up to the down line was also demolished. At the moment of the explosion the down train from Farringdon-street was just entering the station, and the concussion was so great as to break some of the windows in the carriages of that train, and to burst the gasholders on the roofs of the carriages. The driver, stoker, and a few of the passengers were slightly injured.

Collision on the Midland Railway.—On the evening of the 12th ult. a collision took place on the Midland Railway, Nottingham, unattended with fatal results. The accident occurred to an express train which leaves Birmingham at 6·50, and is due in Nottingham at 8.50. About the time it was due the engine of a shunting train, the driver of which, it was supposed, was misled by the signals, got foul of the arrival line, one buffer projecting upon and facing towards the bridge. The express came up at its usual speed, moderated then to about ten miles an hour, and it was not till it had passed through the bridge that the driver saw the obstruction that was close upon him, and there was time neither to reverse the engine nor to jump from the train. The driver of the shunting engine heard the approaching train and attempted to back down the siding, but it was too late to avoid a collision. All the passengers, about twelve in number, were more or less injured.

BOILER EXPLOSIONS

Locomotive Boiler Explosion at Colne.—At about three o'clock on the morning of the 5th ult., the boiler of a locomotive engine, just arrived from Leeds, suddenly exploded at the railway station at Colne. The engine-driver was instantly killed, and his companion, the stoker, seriously injured.

Boiler Explosion at the Wallsend Ironworks.—On the 13th ult., at noon, while the workpeople were at dinner, a boiler explosion occurred at the Wallsend Ironworks. The workmen had left the premises, with the exception of the two stokers, who remained and were getting their dinner by the furnace fire. One of them was killed on the spot, and the other was much injured. The bottom part of the boiler, weighing about three tons, was carried to a considerable height, and alighted about 200 yards from its original bed. A good deal of damage was done to the adjacent premises. At an inquest Mr. M'Kay, the superintendent of the boiler department at Messrs. Hawthorn's factory, stated that the boiler was a strong one, the materials and workmanship being extremely good, and calculated to maintain a pressure of 200lb. to the square inch before it would explode. The engineer, however, stated that there was not more than 30lb. pressure when the boiler burst. The boiler had been laid off for cleaning, and had only been filled a short time previous to being set to work again when the explosion took place.

Explosion at the Kepier Grange Colliery.—An explosion took place at Kepier Grange Colliery, a mile and a half east of the city of Durham. It occurred between twelve and one o'clock on the 13th ult. The first boiler of those employed in connexion with the machinery at bank was that which had exploded, and it was blown to pieces; the next one was torn from its bed, and the third was displaced. The fireman and two boys were killed. Three other children were found to be severely scalded. The boiler had parted, broken into three pieces, and one of these was carried 100 yards off. The engine house was stripped of its roof, and a great deal of damage was done by the explosion.

DOCKS, HARBOURS, BRIDGES, &c.

New Bridge between New York and Washington.—The new bridge now being built on the railway route leading from New York to Washington, across the Susquehanna river, at Havre de Grace, will be 3,800ft. long, and supported by 13 stone piers each 240ft. apart; seven of these will have pile foundations, and six rock. They will be constructed so as to resist the greatest pressure of ice which it is possible to bring against them. The greatest depth of water in which these piers are laid is 42ft. The bridge will have a "draw" on the pivot plan, with two openings of 70ft each in width. The railway track will be 25ft. from the water; above that will be a common carriage way. The entire height of the bridge will be 50ft., its estimated cost 700,000 dols. It was intended to build the superstructure of iron, but the high price of that material may cause the substitution of wood.

New Bridge Over the Trent.—A new bridge has been constructed over the Trent, belonging to the South Yorkshire Railway Company. The Trent is at this point 475ft. wide and 18ft. deep at low water. The bridges made of iron girders resting on tubular piers, is of five spans, and, by means of a turntable, provides two channels for the navigation, each 60ft. wide. The turntable is easily worked by two men, and the bridge opened in four minutes. The under surface of the bridge is 27ft. above low water mark. The width of the bridge between the girders is 22ft., and the girders afford a footpath for the company's servants. The bridge has been made by Messrs. Fairbairn & Co., from the design of Mr. Bartholomew, and has cost £40,000.

Bridging Niagara River.—A bridge is to be built over Niagara river at Buffalo, to connect with Canada, at a cost of 1,000,000 dols. Over 300,000 dols. have been subscribed towards it.

MINES, METALLURGY, &c.

British and America Copper Mines.—A Californian paper states, that during 1862, the Lake Superior Mines sent to market three-fifths as much copper as was obtained from all the British mines, and the yield for the present year will probably exceed that of the English mines. In Great Britain the copper mines have been worked for centuries, whereas less than a score of years have elapsed since the first ton of native copper was shipped from Lake Superior. In Great Britain the copper mines are yielding a diminished product. At Lake Superior, virgin veins and lodes are every year uncovered and developed, the yield being rich and unfailing, and the prospect being full of profit and promise. These results are most encouraging to the copper mines of California. Lake Superior, in less than a score of years, has increased her yield of copper to an extent equal to that which Great Britain has attained only after the lapse of many centuries. Neither is there any danger of overstocking the market, for although the yield of copper has been doubled within a few years, so great has been the increase in demand that its price has been constantly enhancing. The demand will be fully equal to the increasing yield.

Crystallised Iron.—Crystallised iron, "or Franklinite," states an American mining paper, is the production of the mine of the New Jersey Zinc Company. There is but one mine of this ore in the world. The zinc being first extracted from the ore, the residue is the brilliant and singular metal which we have named "crystallised iron." For many years no use was made of this metal, and it was simply kept in small specimens in gentlemen's cabinets, as a curiosity. However, a use has at last been found for it, and since it has proved so superior in this instance, many other avenues for its introduction are now opening; and it bids fair to prove, not only one of the most remarkable, but one of the most useful and valuable metals the world has ever known. As preventive against drilling, when combined with wrought-iron and steel, it is the only real protection against a burglar now in use. Chilled iron, by late improvements in hardening drills, can be easily bored. Hardened steel is not only so brittle as to be almost useless, but its temper can be drawn by a blow-pipe, and then it is at the mercy of the burglar's tools. With the crystallised the case is different; it can be furnished any thickness, is not so brittle, as any other hard metal, cannot be affected by a blow-pipe, and is the hardest material to bore through ever yet produced.

GAS SUPPLY.

The Brighton and Hove Gas Co. have made a reduction in the gas supplied to the town of New Shoreham. The present reduction will be 6*d.* per 1,000ft., and a further reduction of 6*d.* will be made in March, 1865. The superintendent of the Brighton Company was closely questioned, at a meeting on the subject, as to the low price charged at Plymouth. The meeting resolved that the reduction in price promised should begin at Midsummer, 1864, instead of March, 1865.

The Market Rasin Gas Co. are now engaged in making considerable additions to their works. An excavation, closely abutting upon Nursery-street, has been made for the placing of a second gasometer.

London Gas Companies.—It appears from official returns that the total sum received by thirteen metropolitan gas companies in 1862 was £1,840,969, and that the total working expenses were £1,282,566, leaving a balance of profit of £558,403. After providing for £41,112 for interest on debentures, the companies had still £517,291 available for dividends on their shares. The receipts of each company were as follows:—Chartered, £276,336; City of London, £114,523; Commercial, £123,754; Equitable, £83,798; Great Central, £91,385; Imperial, £475,428; Independent, £78,738; London, £170,724; Phœnix, £170,588; Ratcliffe, £36,013; South Metropolitan, £78,663; Surrey Consumers, £62,129; and Western, £78,890. The working expenses of each company in the same period were:—Chartered, £203,969; City of London, £83,390; Commercial, £85,515; Equitable, £40,152; Great Central, £60,027; Imperial, £333,986; Independent, £60,341; London, £119,098; Phœnix, £214,852; Ratcliffe, £24,438; South Metropolitan, £55,548; Surrey Consumers, £41,392; and Western, £50,858. The profits realized by each undertaking were accordingly:—Chartered, £72,367; City of London, £31,133; Commercial, £38,239; Equitable, £34,646; Great Central, £31,358; Imperial, £141,442; Independent, £18,397; London, £51,626; Phœnix, £55,736; Ratcliffe, £11,575; South Metropolitan, £23,115; Surrey Consumers, £20,737; and Western, £28,032.

WATER SUPPLY.

The Bradford Reservoirs.—On the 20th ult. the Waterworks Committee of the Bradford Corporation had placed before them the report of Mr. Rawlinson, C.E., to Sir George Grey, giving the results of his recent inspection of the various reservoirs belonging to the corporation. The report concludes thus:—"That the Bradford reservoirs, conduits, aqueducts, and other works have been well devised, and, with the exception of leakages at Doe-park reservoir, and at Barden, appear to be well executed. That the rule as to the bywash space adopted by the engineer in proportion to the area of the several grounds is ample. That outlet culverts and valve wells designed by Mr. Leather on the Bradford reservoirs are very much to be preferred to cast-iron pipes laid through or under the deepest part of the embankment. That reservoir embankments are liable to subside for several years after they have been made. That such subsidence should be immediately attended to, so as to preserve the embankment at the full height above the overflow, as designed by the engineer. That all reservoirs where water is impounded by the embankment, as at Doe-park and other large reservoirs, there should be a night and day watchman or attendant. Below Doe-park are working colliery shafts within reach of a flood such as occurred at Sheffield. There is much valuable property on the stream below. This reservoir at the time of inspection was in a dangerous state, and the utmost care should be taken to make the work of its embankment secure so as to avoid risk in future. This latter remark applies also to Barden reservoir embankment. This report must not be understood to involve the Government and himself (Mr. Rawlinson) in any responsibility. Reservoir embankments and works in connection with them cannot positively be pronounced upon by a mere examination of plans, specifications, reports and surface inspections.

APPLIED CHEMISTRY.

Dulos' Processes of Engraving.—A copper plate, on which the design has been traced with lithographic ink, receives, by the action of the pile, a deposit of iron on the parts untouched by the ink; the ink having been removed by means of benzine, the white portions of the design are represented by the layer of iron, and the black by the copper itself; the plate is then plunged into a bath of cyanide of silver, under a galvanic current, and the silver is deposited on the copper only. In this condition mercury is poured over the plate, which attaches itself to the silvered portions only, appearing in relief, and taking the place of the lithographic ink. Then take, in plaster or melted wax, an imprint, the cast of which presenting the counterpart of the projections of mercury, gives a kind of copper plate engraving. This cast has not sufficient strength to bear the press; but by metallising the mould, and depositing upon it, electro-chemically, a layer of copper, we obtain an exact reproduction of the original projections of mercury, and in some sort a matrix by means of which impressions of the plate may be produced *ad infinitum*. For typographic engraving (figures in relief), the plate of copper should receive, on leaving the hands of the designer, a layer of silver, deposited only on the parts untouched by the lithographic ink; the ink is removed by benzine, the surfaces first covered by the design are oxidised, and the treatment above described is continued. At the end of the operation the raised portions of the electro-chemical plate intended for the impression will be found to correspond with the tracing of the design, and the hollow portions with the thickenings raised about the design by the mercury. This process, which is the starting-point and the basis of M. Dulos' invention, has led him to the discovery of some more simple methods, which have led to important practical results, the fusible metal or amalgam of copper substituted for mercury giving rapid and remarkably perfect results.

Decomposition of Water by Phosphorus, Arsenic, and Antimony, under the Influence of Nitric Acid, with Production of Ammonia, by M. Personne.—The solution of phosphorous in nitric acid, concentrated or diluted with one or two volumes of water is, as is well known, effected with disengagement of nitrous vapour, abundant if the acid is concentrated, and diminishing in proportion as it is more diluted. In any case if, when the solution is effected, excess of potash is added to the hot solution, sufficient ammonia is disengaged to become evident, both by re-agents and by its odour. Whether normal or amorphous phosphorous is used in this operation, the phenomena and the products are identical. It was interesting to ascertain whether the fact of the production of ammonia was observable with the bodies forming part of the phosphorous group, as arsenic and antimony. I operated with distilled arsenic and with antimony purified three times by fusion with nitre. These two bodies pulverised and heated were attacked by nitric acid, diluted with its volume of water. Under these circumstances arsenic is easily attacked, giving arsenious acid and a little arsenic acid; antimony, on the contrary, is attacked with more difficulty. However that may be, if ammonia is looked for in the liquids obtained it will be found that these two bodies have behaved like phosphorous, with this difference, that phosphorous gives more ammonia than does arsenic, and arsenic more than antimony. The phenomenon of the formation of ammonia by the decomposition of water under the influence of nitric acid has hitherto been observed only with metals of the third and fourth section, as iron, zinc, tin, &c. The above observations show that this phenomenon is not limited to these metals, but belongs equally to the metalloids of the phosphorous group.

Preparation of Suboxide of Copper, by M. R. Boettger.—Suboxide of copper, says M. Boettger, is obtained in great perfection by the following process:—Dissolve in 2 parts of hot distilled water, 1 part of crystallised sulphate of copper, 1½ part of tartrate of potash and soda, and two parts of cane-sugar; when the solution is complete, and tartrate of copper formed, add 1½ part of caustic soda. By boiling the mixture, the suboxide of copper is gradually precipitated, losing its odour completely, as in saccharometric experiments. The product is of a beautiful red colour, and after it is washed and dried will keep without alteration; before being dried, the author advises its being washed in a little alcohol.

Some Curious Properties of Oxide of Silver, by M. Boettger.—M. Boettger has remarked that oxyde of silver yields its oxygen to combustible matters quite as readily as does peroxide of lead PbO_2, which, on account of this property, is very largely employed in the manufacture of chemical matches. A very dry mixture of about two parts of oxide of silver and one of sulphur ignites by friction in a mortar or even between folds of paper. It makes no difference if the antimony compound is replaced by black sulphide of antimony, realgar or piment. The same thus occurs with amorphous phosphorous as with tannin. Gallic acid does not induce combustion. A drop of phenic acid or creosote poured on very dry oxide of silver causes an instantaneous flame. Flour of sulphur also ignites when triturated with this oxide; selenium the same.

LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT, OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF THE ARTIZAN."

DATED APRIL 23rd, 1864.

1031 B. F. Brunel—Treating vegetable fibres
1032 J. J. Smyth—Drills
1033 T. H. Holderness & H. Jordan—Construction of ships
1034 R North—Smoke consuming apparatus
1035 F. G. Grice & H. Bennett—Hollow iron keys or wedges
1036 H. Bennett—Puddling iron, steel iron, and steel
1037 J. Dodge—Hardening saw blades and other sheets of steel
1038 J. F. Brinjes — Apparatus for re-burning animal charcoal

DATED APRIL 25th, 1864.

1039 H. Marsden—Carding engines
1040 W. Crofts—Propagation of oysters
1041 W. E. Newton—Connecting jacquard cards together
1042 A. J. Billing & J. Shore—Rack pullies for window blinds
1043 J. Symes—Urinals
1044 D. Harris—Billiard tables

DATED APRIL 26th, 1864.

1045 G. Haseltine—Rotary pumps
1046 Sir C. Fox—Driving wheels of locomotive engines
1047 W. Taylor—Spinning cotton
1048 F. Bush—Nail cutting machines
1049 T. S. Truss—Carrying knapsacks
1050 J. Russell, jun.—Hewing coal and other minerals
1051 W. Thorold—Condensing steam

DATED APRIL 27th, 1864.

1052 E. Taylor—Churning
1053 H. S Jacobs—Wheel dressing machines
1054 L. A. Durrien—Spring seats
1055 J. White—Ladies' mourning bonnet and hat falls
1056 T. J. Searle—Washing and wringing clothes
1057 T. L. Southgate—Omnibuses
1058 B. F. Brunel—Treating titanic iron sands
1059 R. A Brooman—Holding bits and other metal parts of harness and saddlery while being cleaned and polished
1060 R A. Brooman—Producing photographic pictures photogenically indelible
1061 S Bateman—Paddle wheels of steam boats
1062 E. J. W. Parnacott—Grinding and polishing surfaces

DATED APRIL 28th, 1864.

1063 L. E C. Martin—Apparatus for generating steam
1064 J. Cookson—Self-acting valves
1065 J. Parker—Application of steam combined with air as a motive power
1066 R. Melling, jun.—Wheels of carriages for common roads
1067 C. O. Papengouth—Armour plating and batteries of war
1068 C. H. Pearson—Felling trees
1069 A. Notman—Hinges for ships' ports, skylights, and other purposes
1070 A. V. Newton—Vices
1071 G. Schaub—Transmitting currents of electricity for telegraphic purposes
1072 T. G. Ghislin—Treatment and application of sea-weed

DATED APRIL 29th, 1864.

1073 M. A. F. Mennens—Capsulation of fluid medicines
1074 T. Cordukes & J. G. McGee—Railway wheels and axles
1075 F. T. Aldridge & M. J. Jackson — Making hats perfectly grease proof
1076 R. H. Smithett & J. Davidson—Treating clay and artificial stone
1077 J Davidson—Bricks
1078 R. H. Smithett—Connecting bricks together for building purposes
1079 J. Corry—Projectiles for smooth bored ordnance and small arms
1080 J. Little—Pavement for streets, roads, and thoroughfares
1081 R A. Brooman—Treating wood and other ligneous substances
1082 J. McCall & B G. Sloper—Preparing and preserving food
1083 W. C Cambridge—Iron
1084 J. C. Browne—Raising vessels and other sunken bodies
1085 J. Harvey—Obtaining and applying motive power
1086 D. C. Davies—Roof lamps for railway and other carriages
1087 F. C. Hills—Gas
1088 F. C. Hills—Purification of gas

DATED APRIL 30th, 1864.

1089 O. C. Burdict—Nuts
1090 J. K. Crawford—Producing ornamental fabrics
1091 J., T. J., & J. Parker—Cleaning dried fruits
1092 F. Leisz—Syrups
1093 L. Prang—Preparing paper for holding photographs
1094 R A. Brooman—Glass for gas burners
1095 R. A. Brooman—Tanning
1096 J. Mieussey—Milliners' work boxes
1097 D. Clarke—Venetian blinds
1098 J. Bessac—Revolving hair brushes
1099 M. P. W. Boulton—Steam and caloric engines
1100 J. L. Norton, F. Gregory, & J. Salmon—Presses
1101 J. Huut—Ornamenting the globes and shades of lamps
1102 J. H. Johnson—Looms for weaving figured fabrics
1103 W. I. Meacock—Anchors
1104 G. Gell & W. Cafferata—Cleaning beans, wheat, and other grain
1105 F. S. Barker—Pumps

DATED MAY 2nd, 1864.

1106 F. Parker & H. Hitzman—Revolving brushes
1107 P. A. L. de Fontainemoreau—Washing ores and other substances
1108 A. V. Newton—Projectiles

DATED MAY 3rd, 1864.

1109 J. O. Bradley & R. Fielding—Counter slip note books
1110 S Shaw & H. Fishwick—Stamping and embossing textile fabrics
1111 A W. Gittens—Finishing photographic pictures and marbled papers
1112 M. P. W. Boulton—Obtaining motive power by the combustion of fuel
1113 P. Ward—Lubricating compounds
1114 E H Newby—Iron and steel
1115 D. Neviu & W. Coppin—Separating the woody parts from the fibrous portions of flax and hemp
1116 R. Thompson—Planing metals
1117 R. Garrett, jun —Steam cultivation
1118 W. Smith—Artificial fuel

DATED MAY 4th, 1864.

1119 E. Beanes—Treating animal charcoal
1120 J. McDowell—Carriages
1121 R. Hammerton—Miners' safety lamps
1122 Y. Parfrey—Filling, closing, and finishing cartridges
1123 W. McVitie—Inducing the circulation of a liquid for condensing or refrigerating
1124 J. Potter—Artificial stone
1125 T. H. Rees—Blue colouring matters for washing purposes
1126 W. T. Henley—Telegraph cables
1127 M. Cochran—Floating fire engines
1128 J Thompson—Securing stoppers in bottles
1129 A. V. Newton—Anchors
1130 W Jarvis—Brakes for carriages
1131 C. J. Richardson—Steam boiler and other furnaces

DATED MAY 5th, 1864.

1132 J. Gardner, R. Lee, & G. H. Wain—Straps for pulley blocks
1133 W. Davies & G. & W. Cate—Cutting corks and bungs
1134 T. Evans—Sewing machines
1135 H. H Henson—Armour and other plating and sheathing for ships
1136 E. Beanes & C. W Finzel—Sugar boiling
1137 R. A. Brooman—Wheels
1138 A. V. Newton—Generating heat
1139 G. Haseltine—Steam engines
1140 W. Simpson—Twist lace machines
1141 L., J., C., L., & M. Jefferson—Railway brake apparatus
1142 J. J. Miller, jun.—Steam engines and pumps

DATED MAY 6th, 1864.

1143 J. Shortridge—Iron
1144 W. Robertson—Machines for spinning and doubling
1145 J. H. Poole & J. Asthury—Improvements in puddling machines
1146 G Hodgson & A. H. Martin—Giving motion to rotary shuttle boxes of looms
1147 J. Turnbull—Masting of ships
1148 W. Hirst—Linen spool tubes
1149 A. Rieder — Shades, spectacles, and eye glasses
1150 C. P. Stewart & J Gresham—Winding yarn on to bobbins and spools
1151 A Barclay—Apparatus for injecting and ejecting fluids
1152 A. Swonnell—Scarfs
1153 J. Tomlinson—Applying motive power in the traction of omnibuses
1154 F Martin—Anchors

DATED MAY 7th, 1864.

1155 J. H. Johnson—Protecting parts of boots and shoes
1156 J. H. Johnson—Economising the consumption of gas
1157 J. H. Johnson—A new article of dress
1158 J. Worsh—Ship and other lamps
1159 J. Cameron—Construction of lever punching machines
1160 E. R. Handcock—Engines to be worked by steam or other motive power
1161 A. V Newton—Facilitating the inhalation of medicinal substances
1162 J. R. Abbott—Gasaliers, chandeliers, and other sliding pendant lamps
1163 W. Powell—Breech-loading fire-arms
1164 A. Upward—Boring and tapping gas and water mains
1165 E Heywood—Stretching and finishing fabrics
1166 H. Woodward—Carburretting gas

DATED MAY 9th, 1864.

1167 E. Tombs—Crinolines and trimmings
1168 W. E Gedge—Shade for gas or other lights
1169 J. F. Empson—Material for covering buildings and other structures
1170 J. Chambers—Making bricks
1171 J, J, D., & H. Whitehead—Manufacture of hooped skirts
1172 H. Aitken—Calcining and extracting the oils and gases from ironstone
1173 F. H. Wenham—Motive power engines worked by explosive mixtures
1174 D. F. M. M. del Real—Extracting silver from lead
1175 W. G. Haig—Umbrellos
1176 G. Pulsford & G. Walkland—Lace
1177 J. Roy—Self-acting mashing apparatus
1178 A. V. Newton — Heating and evaporating fluids

DATED MAY 10th, 1864.

1179 A. Silvester — Obtaining certain theatrical effects
1180 T. W. & R. Condron & G. R. Hartsborne—Brushes
1181 J. A. Wanklyn—Manufacture of purple dyestuffs from manna-sugar
1182 S. Dreyfous—Air-canes or pea-shooters
1183 D. Butler—Steam hammers
1184 J. Rowland—Cocks, taps, and valves
1185 M. Morgans—Blast furnaces
1186 F. Coney—Brushes
1187 N. Thompson—Stopping bottles, jars, and other vessels
1188 D. Jon s & B. I'Anson Bromwich—Preservation of liquors

DATED MAY 11th, 1864.

1189 J. Moore—Machines for reaping and mowing
1190 J. Yule—Steam hammers
1191 T. Walker—Utilisation of sewage matters
1192 J Brown & A. P. Price—Manufacture of blotting paper
1193 W. Weild—Casting ingots from metal prepared by Bessemer's process
1194 J., J., & J Booth—Cranes
1195 A. Alison & J Halliwell—Atmospheric railways
1196 T. M. Gisborne—Kilns for burning bricks and tiles

DATED MAY 12th 1864.

1197 C. Martin—Carriages
1198 R. Wilson—Hydraulic and other presses
1199 O. Sachs—Analyne dye colours
1200 J. Phillips—Purification of coal gas
1201 T. Parker—Gasaliers
1202 S. Robinson—Name plate, letter receiver, and bell-pull for doors
1203 W. Horne—Treating canvas, tarpaulings, or other painted canvas
1204 J. L Norton — Tentering, stretching, and drying fabrics
1205 T. N. Kirkham & V. F. Ensom—Cleaning, bleaching, and dyeing woven fabrics
1206 M. P W. Boulton—Obtaining motive power from steam or aeriform fluids
1207 H. A. Bonneville—Stockings and socks
1208 R. D Dwyer—Cleaning the bottoms of iron and other ships
1209 J. Dodgeon, J. Gaukroger, & W. Shackleton—Looms for weaving
1210 R. F. Fairlie — Locomotive engines and boilers

DATED MAY 13th, 1864.

1211 E. Myers & T. G. Progers—Wet gas meters
1212 A. Gall—Fire grates
1213 A. Goodrich—Carriages to be propelled by the human body
1214 G. T. Bousfield—Screws
1215 R. A. Brooman—Screw propeller
1216 G. Haseltine—Portable drilling machinery
1217 M. Henry—Apparatus for indicating, measuring, counting, and registering
1218 D. Bateman—Card cloth and other water and oil proof fabrics
1219 R. H. Hughes—Heating dinner-plates, dishes, and cups
1220 C. Liddell—Breakwaters
1221 D. West—Fireproof railway vans, trucks, and carriages

DATED MAY 14th, 1864.

1222 R. Griffiths—Propelling ships
1223 E. W. Furrell—Communicating between the guards and the engine drivers of railway trains
1224 B. Gate & M. Walsh—Twisting and doubling yarn and thread
1225 P. Craven—Fringe.
1226 F. Blackwell—Punching metal
1227 W. E. Newton—Rotary engines
1228 A. Fryer—Treating animal charcoal in the process of revivification
1229 L. Bricout—Carburetting gas
1230 R. Jones—Self acting money till

DATED MAY 16th, 1864.

1231 J. Brady—Crinoline skirtings
1232 J. Womersley—Paper
1233 W. E. Newton—Mules for spinning
1234 W. Reid—Testing the insulation of electric telegraph wires

DATED MAY 17th, 1864.

1235 L. L. Sovereign—Agricultural implement for cultivating land
1236 W. Wilson—Generating gas
1237 A. Mackie & J. Salmon—Obtaining impressions from typographic surfaces
1238 G. Chambers—Bags
1239 T. Wilson—Carriages
1240 J. Fletcher—Reaping and mowing machines
1241 P. G. Etesse — Mouldings and ornamental devices on wood
1242 J. Hamilton, jun.—Electric telegraph posts
1243 R. A. Brooman—Dyeing wool
1244 G. Hunter—Cutting marble, stone, slate, and coal
1245 W. Rowan—Treating flax
1246 S. Foster & W. Rowden—Reefing and furling the sails of ships or vessels
1247 P. Bawden and J. and S. Williams—Making bricks

DATED MAY 18th, 1864.

1248 W. Wanklyn—Ginning cotton
1249 H. A. C. Boulenger—Moulding and shaping plates
1250 P. M. Parsons—Ordnance and projectiles
1251 T. Dean—Buttons
1252 R. Smith—Obtaining colouring matters
1253 R. Rimmer—Instrument for laying hold of asparagus and globe artichokes
1254 J. B. Merrikin—Bottles
1255 P. S. G. Græme—Ships or vessels for war
1256 W. Adkins—Lever wrench or self-adjusting spanner
1257 A. B. Childs—Separating grain
1258 J. Webster—Zinc
1259 J. Browning—Lamps
1260 G. Fagg—Paving roads and ways

DATED MAY 19th, 1864.

1261 G. Homfray—Forming the links of iron or steel chains
1262 T. Dunlevie and J. Jones—Metallic alloys
1263 W Bauer—Self-acting governors
1264 J. Combe and J. H. Smalpage—Winding cops
1265 F. Deletang—Communicating rotary motion to shafts and axles
1266 W. Dray—Raising weights
1267 W. R. Harris—Carding engines
1268 W. Sargeant—Horse hoes and seed drills
1269 J. Frazer—Breech-loading fire-arms
1270 J., E. G , and C. H. Freeman—Treating oil and spirit varnishes

DATED MAY 20th, 1864.

1271 H. Defries—Wick holders for lamps
1272 E. Wilson—Looms for weaving
1273 F. Noble—Raising water
1274 E. A. Cowper—Separating cotton fibre from the seed
1275 S. R. Dickson—Ploughs
1276 E. Hodges—Harmoniums
1277 W. Tasker—Thrashing machines
1278 W. E Newton—Fuses for projectiles
1279 J. B Ilburn and G. Valentine—Measuring and blocking woollen and other fabrics

DATED MAY 21st, 1864.

1280 C. Menasi—Hatching eggs and rearing birds artificially
1281 J. Edwards—Fastenings for articles of dress
1282 J. O. Winkles—Fastenings for sleeve links, solitaires, and other articles of jewellery
1283 J. Fowler, jun —Horse shoes
1284 W. G. and J. H. Todman—Presses for printing or stamping
1285 C. P Coles—Protecting the bottoms and sides of wooden and iron ships
1286 R. A. Brooman—Enriching lighting gas and production of gas

DATED MAY 23rd, 1864.

1287 J. L. and J. Hinks—Attaching knobs to doors and the surfaces of other articles, and to lock and latch spindles
1288 J. E. Holmes—Raising, lowering, or conveying fluids or solid bodies by atmospheric pressure
1289 W. Howlett—Printing floor cloths, carpets, and other similar goods
1290 G. T. Bousfield — Machinery for cutting files

DATED MAY 24th, 1864.

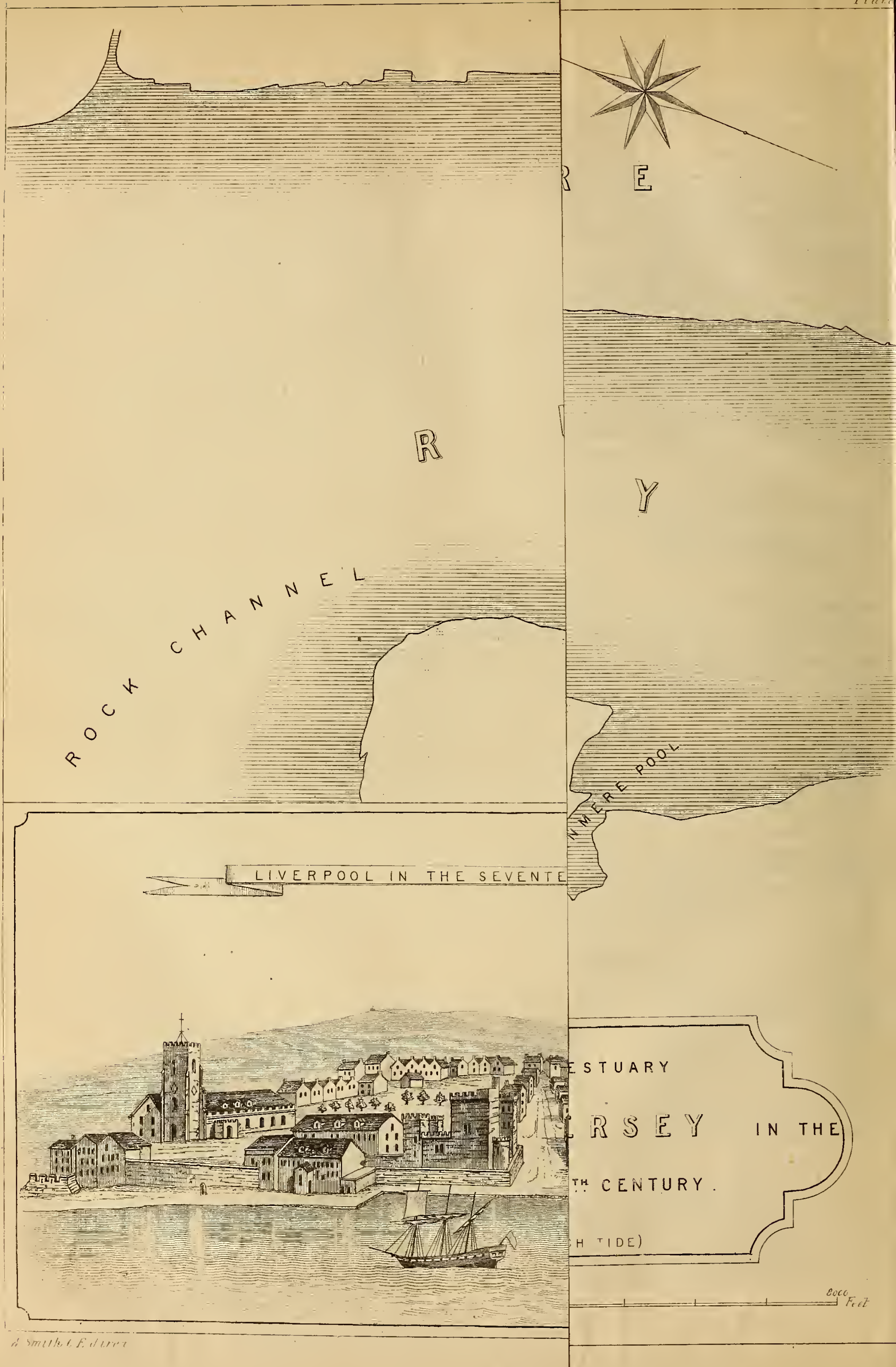
1291 M. P. W. Boulton—Engines worked by means of heated air or gases and steam
1292 J. W. Goundry—Organs and other wind instruments
1293 J. Adams—Apparatus for drawing and regulating the flow of fluids
1294 W. Clark—Manufacture of festooned edging or trimming

DATED MAY 25th, 1864.

1295 P. Ross—Handle or stock for tools and other articles
1296 B. Jones—Obtaining sulphur from alkali or blue waste
1297 G. Moulton—Turntables applicable to overhead railways
1298 W. Passmore — Making sewing machines, rotary hair-brushing machines, model machinery, electrical apparatus, small lathe or other machinery to which hand, line, or cog is applicable, self acting
1299 W. Law—Dress fastening
1300 G. Shaw—Heating the steam boilers of stationary, locomotive, and marine engines and stoves
1301 J. Baird and J. McIntyre—Clearing and bleaching textile fabrics
1302 J. E. Whiting—Girders for bridges and other structures
1303 G. Schaub—Transmitting currents of electricity for telegraphic purposes
1304 H Wimshurst—Fitting screw and similar propellers for propelling ships and vessels

DATED MAY 26th, 1864.

1305 R. Holiday—Railway chairs, chairs for points, and levers for points
1306 G. Davies—gloves
1307 H. Redfern—High-pressure cocks, taps, or valves
1308 L. Stevenaux — Sweating rooms for drying malt and other grain
1309 L. A. W. Lund—Studs, buttons, sleeve links, brooches, bracelets, and ear-rings
1310 J. H. Brown—Treating animal substances for the manufacture of size, pulp, and pulpy matter



R E
R
Y
ROCK CHANNEL
NMERE POOL
LIVERPOOL IN THE SEVENTE
ESTUARY
RSEY IN THE
CENTURY.
H TIDE)
Feet

THE ARTIZAN.

No. 19.—Vol. 2.—Third Series.

JULY 1st, 1864.

A HISTORICAL AND DESCRIPTIVE SKETCH OF THE MERSEY DOCKS AND HARBOUR.

By J. J. Birckel.

(*Illustrated by Plate* 264.)

The conviction which is deeply rooted in every Englishman's mind that the wealth and greatness of this country are so intimately bound up with its maritime power—so dependent upon the carrying capabilities of its mercantile navy—as to be almost co-extensive and co-existent with the same, may easily be traced in the political tendencies of the English people, and in the readiness with which English capital lends itself to the development of that source of power, both in supporting almost every new maritime or colonial enterprise which is brought into light, and in improving our shipping,—in respect alike of numerical strength, speed, and carrying capabilities,—by adopting every new fact or principle suggested either by science or by experience as tending in that direction.

The truth of these remarks is so completely verified—the former by the jealous watchfulness exercised by the English people over the development of the naval power of other nations, and by the lavish expenditure of moneys in the development of their own; the latter by the readiness with which undertakings like the construction of the *Great Britain* and the *Great Eastern* have found supporters, by the rapid increase in the construction of iron as compared with that of wooden vessels, and also in the construction of steamers as compared with that of sailing vessels—that to dwell upon them for the purpose of further illustration would be a mere waste of time; and though we have deemed it necessary to place them before our readers, it has been merely by way of introducing the matter to be treated of in the sequel.

The necessity, also, for providing shelter to shipping within reach of the coasts during stress of weather is a subject which has not been overlooked, as is evidenced by the pressure put upon our Government with reference to the somewhat vexed question of harbours of refuge, respecting which there are so many rival claims, and such varied opinions concerning their proper position and distribution, that the unconcerned and dispassionate observer can readily understand why those entrusted with the outlay of the public funds should move but slowly in this matter, especially in the face of such observations as we heard made some few years since by a gentleman of much practical knowledge, residing on the east coast, viz., that " Government are wasting a deal of money upon harbours of refuge, for nothing can resist the action of the sea." How much of truth, and how much of error, there is in a statement of this kind we may have occasion to show as we proceed with our subject.

Akin to this subject, and of prior importance, is that of the necessity for providing shipping with the requisite accommodation for loading and unloading their cargo, with shelter while waiting for their freight, and with the means for facilitating such periodical or accidental repairs as circumstances may occasion. This subject presents itself, in its general outline and character, very naturally to our mind; but the precise nature of the accommodation required for the various stages in the career of a ship, and more especially the kind and the extent of accommodation required to meet the wants of a given port, are part-subjects, constituting a whole, the knowledge of which remains as yet but comparatively local and individual. It is but three years since the people of Liverpool were amused to their hearts' content by the proposition gravely made in the mayor's parlour, at Manchester, before a select audience, to convert that town into a sea port; and, within the last sixteen years, the world has witnessed two of the most egregious blunders ever perpetrated by the engineering profession. First, in the case of the *Great Britain,* when the gates of the dock in which she was built were actually too narrow to permit of her exit; secondly, in the case of the *Great Eastern,* which vessel was evidently built without a careful consideration of the probable requirements for getting her afloat, in consequence of which £100,000 had to be spent in launching her (although it should be mentioned that Mr. Scott Russell had offered to build her in a dry dock, and to set her afloat at the comparatively moderate cost of £10,000), and which vessel appears to have been designed without the least forethought respecting the difficulty of finding a harbour where she might receive and discharge her freight, and where means might be provided for cleansing and repairing her bottom, in consequence of which she ran a fair chance of being lost when lying behind Holyhead, in that heavy gale which occasioned the wreck of the *Royal Charter;* and although it was afterwards discovered that there is one spot in the Mersey where she may ride at anchor at all states of the tide, yet is this no harbour accommodation at all in a commercial point of view, since the operations of coaling, of loading, and of unloading her cargo had all to be performed by the assistance of lighters; for it is worth noticing here that Mr. McIver, the agent and manager of the Cunard steamers has only very recently laid a claim of £300,000 before the Mersey Docks and Harbour Board for losses incurred, or alleged to have been incurred, by his ships, through similar disabilities owing to some fault of the Board. Of the *Great Eastern,* however, we fear it will yet have to be said that the sea is not her element, since in spite of all efforts made on her behalf, she has failed to prosper thereon, and the best and most appropriate uses to which probably she may yet be put are those of a sailor's home, a mariner's church, and a hospital for sick and incapacitated seamen.

It is now a fact well-known to most Englishmen that Liverpool is the second port in the United Kingdom, so far as commercial importance may be calculated, from the tonnage of the shipping entering and leaving a given port in a given time; and indeed, in this respect, Liverpool does not fall so very far short of London. But it is questionable whether the national importance of a given port is really only to be measured by the amount of shipping and its tonnage which enters and leaves that port; as it appears to us that its position both with regard to the sea and with reference to the centres of production, of manufacture, or of consumption which it relieves or feeds, and also the nature of the trade carried through it, should form elements of comparison equal in value with the one element alone of tonnage entered inwards or outwards. Thus it may be said of Liverpool that it supplies the wants of the manufacturing and mining interests of Lancashire, Yorkshire, and Staffordshire, and its position with regard to these districts is such that the raw materials which it delivers to them, and the mineral and manufactured goods which it receives from them have to travel over the shortest possible distance by rail, ensuring thus a minimum of expense in the carriage by land of the staple trade of the country; whereas if the same trade had to be carried through London, the expense of that carriage would probably be four times as great as in the present case, without the advantage of a corresponding reduction in the freight from the port of departure to that of delivery; and in the present relative condition of the manufacturing interests in England and abroad, such an increase of expense might be

LIVERPOOL IN THE SEVENTEENTH CENTURY

sufficient to cause the balance of advantage to lean in favour of our continental rivals. If in juxtaposition with these considerations we state the fact that ordinary vessels can enter the harbour of the Mersey at almost all states of the tide, we have little doubt but that our readers will share with us the conviction that, considered merely as trading ports, Liverpool and London stand on a par, although the port of London may be traced 1,600 years back, and is as ancient, almost, as the British nation itself.

There is, however, another circumstance or feature in the history of any two ports which may serve as a term of comparison as to their relative importance, namely, the rate of progress in their respective development as compared with the increase of the national commerce, since this rate of progress is a true index to the development, and, indirectly, to the growing importance of the particular trade which each port feeds, or to which it serves as an outlet. Measuring, therefore, their relative importance by this standard, Liverpool must be held to far outstrip London (limiting this comparison always to their capacities as trading ports only), for the rates of progression in their respective development are such as to make it a matter of certainty that at no very distant period the amount of shipping entering and leaving the port of Liverpool must be equal to that of London.

This statement might perhaps be sufficiently substantiated by the mere mention of the fact that the shipping accommodation now found at the port of Liverpool is the result of the exertions of scarcely two centuries, whereas London was the chief port of the kingdom before a merchant vessel had entered the mouth of the Mersey; but we hope to lay before our readers in the course of these papers such figures as shall speak more convincingly to that point than the bare mention of this fact.

Liverpool, which was formerly a creek within the jurisdiction of the port of Chester, received its charter as a free port from King John, on the 28th of August, 1207, and this charter was confirmed by his successor, Henry III., in the year 1228; but its trade took little development prior to the discovery of the Western Continent, being confined to that with Ireland and with the western coast of England itself. The causes, however, which have erased Chester from among the list of English ports, seem to have been at work at a very early period in the history of the port of Liverpool, for already in 1550 Manchester and the surrounding manufacturing districts carried their trade through this port, while we find that in 1560 a collection was made throughout the kingdom for the new haven of Chester; and during the reign of Queen Elizabeth, certain privileges were granted to the same port, in the shape of immunity from certain dues or taxes on goods or shipping, because it had so much decayed as to render it impossible for the merchants of Chester to carry on a profitable trade under the same restrictions as formerly. Thus we perceive that the advantage possessed by Liverpool of lying close upon the sea—while at the same time its harbour offered sufficient shelter to the shipping which resorted to it—was in a great measure the cause of its becoming the western outlet of the trade of the country; and being well acquainted with the history of these two ports, the merchant of Liverpool may well look with a smile of complacency upon the aspirations of certain Manchester gentlemen who propose to extinguish Liverpool by making Manchester itself into a cheaper seaport, whose entrance shall be up the mouth of the river Dee; for the silting process which has been going on there for centuries still continues, undoubtedly at a similar rate, and it is idle to speak of cheap harbours which have to be kept open by dredging operations.

Liverpool, however, had another advantage over Chester in the fact that the river Mersey, though an insignificant stream when compared with other rivers, still was capable of being converted into and used as a cheap and direct highway between the manufacturing districts of Manchester and its immediate neighbourhood; while the Dee, which takes its rise in the North-Eastern outcrop of the Welsh hills, could never be of any commercial value, as a means of communication between the port of Chester and any of the manufacturing centres.

This fact also must have been in operation at a very early period in its effects upon the respective fortunes of the two ports, for we find that in the reign of Edward IV., *i.e.*, in the latter half of the fifteenth century, a royal order was issued to reduce the fish weirs in width so as to allow an eight-oared boat to pass up the river from Runcorn to Warrington, and it would appear that from this time forward the subject of rendering the Mersey navigable was not allowed to rest, until the fact was accomplished within the limits mentioned, in 1694, by Mr. Thos. Patten, of Bank Hall, Warrington. Later on, in 1712, Mr. Thos. Steers, the first engineer of the Liverpool Docks, surveyed the Mersey and the Irwell, by order of the gentlemen of Manchester, and gave them an account of the rising of the waters, and of the number of the locks it would require to make these rivers navigable. This object, it is well known, has also been accomplished, an Act having been passed for that purpose in the seventh of King George I.

While these exertions were made to facilitate communications between the producing or manufacturing centre and the port, little attention seems to have been paid either to the condition of the harbour or to that of its approaches, which it appears were hardly known at this period, for we find that in the reign of William and Mary, *i.e.*, at the close of the seventeenth century, Captain Greenville Collins wrote to the following effect in the Coasting Pilot :—

"Being at the back of Hyle sand bring the mill (Bootle), and the wood one on the other, and run in keeping close along Hyle Sand, and so into Hyle lake (Hoylake) and anchor. Here the great ships that belong to Liverpool put out part of their lading till they are light enough to sail over the flats into Liverpool. There is a channel near Formby to go into Liverpool, where there is three fathoms at low water on the bar, but this place is not buoyed nor beaconed, and so is not known. The ships be aground before Liverpool. It is bad riding afloat before the town, by reason of the strong tides that run here, therefore ships that ride afloat ride up at the Slyne (the Sloyne) where is less tide."

This interesting document shows that a century after London had been the coveted prize of hostile fleets, and at a time when England had asserted her supremacy over the sea, and swept the navies of Holland and of France from the face of it, the best approaches to the harbour of the Mersey were as yet unknown; and the port of Liverpool—which, in a commercial point of view, was destined to become the modern Venice by the agency of engineering works, which in magnitude stand as yet unparalleled—had no accommodation whatever for the shipping, by means of which its trade was then carried on.

The want of some accommodation, however, must have been felt in the meantime, and if we may judge from such scanty evidence as we are able to discover, speculation already was rife as to the probable increase in the value of property which would follow in the wake of any improvement to the harbour. Thus we find that Sir Edward Moore, whose ancestors had for several generations been leading and opulent citizens in the borough, writes as follows to his son, some time after the restoration (between 1665 and 1670):—

"In Pool-lane is a most convenient parcel of land (if ever the Pool be cut navigable) to build almost round it, so far as lies to the river, there being not the like place in Liverpool to the river side for cellars and warehouses."

In 1709, at length the Corporation took to the matter of the improvement of the harbour in real earnest, when, at their request, the representatives of the borough in Parliament sent down a professional gentleman (Mr. Thomas Steers) to make plans of a dock; in the same year, also, the Corporation applied to Parliament for the necessary powers to carry out that work; and though they were opposed by the cheesemongers of London on the ground that the dock might prove detrimental and dangerous to the shipping collected in it, their application proved successful, and the first dock act was passed in 1710. The Corporation at once gave £500 towards the requisite funds, and though the work proceeded but slowly at the beginning—as might be expected since this was the first dock of the kind ever built in England, and the first estimate (£10,000)

of cost was in consequence considerably below the mark—yet was the beginning fairly made, and from that time forward it has gone on extending without marked interruption, and keeps going on at a daily increasing ratio.

To the honour of the men of Liverpool it must be said that no public undertaking managed by a corporate body, or by a body of trustees, could have been, nor, we believe, could be freer from jobbery than the rearing of the Mersey Dock estate. Here we can find no buying and selling, no gambling in the land upon which stands that long line of docks and river wall to which the bare eye can see no end—no misuse of the powers possessed by the Corporation to levy tolls and dues—no dabbling in the funds of the dock estate for private gains or selfish purposes, although, until very recently, its management was free from any superior control, and rested solely with the corporate body. There seems to have been a unanimity and consistency pervading five or six generations in the pursuit of the object to be accomplished, evidencing from the very birth of the undertaking to this day, that there seems to have been an unflinching purpose to make the best usage of the means at command, to employ the greatest possible amount of intelligence in the design and conduct of this work.

How far the territorial magnates—the representatives of the houses of Derby and Sefton—whose influence must have been, and whose interests still are, very great in these parts—how far they may have been personally instrumental to this end, it is difficult to learn at this period in the history of the port. But we have indirect evidence that the representatives of these noble houses have been favourable throughout to the efforts made by the corporate body towards the development of the resources of the port, in the fact that the sales of the land upon which the dock estate is reared, and which was chiefly in their possession, have always been made in a liberal spirit, without undue hindrances and without unreasonable restrictions. On this ground also may it be said that, however staunch conservatives the Earls of Derby may have been in matters of state policy, yet have they, even in a national point of view, exercised a wise and liberal judgment in the management of their property on the banks of the Mersey.

The transactions which the Earls of Sefton and their ancestors, the Lords Molyneux, have had with the corporate body in respect of their estate and privileges lying near, and connected with this borough and the harbour, have been fruitful in benefits to the Corporation which may be reckoned by millions, and in general results so important and palpable that they deserve to be recorded here, not merely on historical grounds, but because also we may by so doing enable our readers to do justice to the memory of men who have long since passed away from amongst us, for their great wisdom and far-seeing judgment in commercial and economic science.

Thus we find that the lordship of Liverpool, which for several generations had been held in fee farm by the Lords Molyneux as hereditary governors of the castle there, was sold by King Charles I. to the Common Council of the City of London, with other manors, in payment of a loan of £222,897 2*s*., granted by them to King James I., and of two other loans of £120,000 and £25,000 respectively, granted to King Charles I., and that it was bought in 1635 by Lord Molyneux for the sum of £450, subject to a chief rent to the Crown of £14 6*s*. 8*d*. per annum. Among other rights and privileges attaching thereto were those of levying dues and tolls on goods and shipping, and of ferryage across the Mersey, as will be seen from the following abstract of the deed of sale to the Londoners :—

"The said King Charles, in further fulfilment, &c., &c., did give and grant to Edward Ditchfield, John Heighlord, Humphrey Clarke, and Francis Mosse, their heirs and assigns for ever (with other manors, &c.), all that our town and lordship of Litherpool, with every of their rights, members, and appurtenances; and all that boat and passage over the water of Mersey there, and the butchers' shambles in the town of Litherpool aforesaid, and also all stallage and tolls of markets and fairs, with the perquisites of courts in Litherpool aforesaid. And all customs, anchorage, and keytowle (quay tolls) of the water of Mersey aforesaid, and within the town or lordship of Litherpool, then or late in the tenure of Richard Molyneux, Knight, or his assigns, by a particular thereof mentioned to have been of the yearly rent or value of £14 6*s*. 8*d*."

The boat and passage over the water of Mersey here spoken of, formerly belonged to the priors of Birkenhead, by virtue of a grant from King Edward II. in the eleventh year of his reign, but seems to have been appropriated by the Crown with all other ecclesiastical property during the reign of King Henry VIII.

The chief rent of £14 6*s*. 8*d*., with which it was still charged, was subsequently bought of the Crown by the Lords Molyneux, who thus became absolute possessors of the seignorial rights and privileges of the manor or lordship of Liverpool, but kept them for a comparatively short period only, since in 1671 they were leased for a 1,000 years to the Corporation at a rental of £30 per annum; and in 1777 the Earl of Sefton (Lord Molyneux) sold to them the reversionary right for the sum of £2,250, excluding, however, from this sale "the ferry-boats and battleage, and passage over the water of the Mersey."

This ferry—the Birkenhead and Tranmere—will ultimately, therefore, return into the hands of the Earls of Sefton; but as it is probably the least productive of the various ferries since established under the powers obtained by the Birkenhead and the Wallasay commissioners, it will prove of little value to them.

With reference to the sale last mentioned, Baines, the historian of Liverpool, writing in 1851 states that "by this arrangement the Corporation was secured in the possession of dues and tolls, which now produce an income of £100,000 a-year;" and further says that the people of Liverpool must for ever be grateful to the then managers of the Corporate estate, and look upon them as the greatest benefactors of the borough.

When, in 1857, the Manchester interest, jealous of the prosperity of Liverpool, won the day in Parliament, and wrested from the Corporation the right of levying tolls and dues on goods and shipping, they only half succeeded in their object, since it was manifestly unjust to strip that body of a source of income to which they had a clearly-established title, for the Mersey Docks and Harbour Board which was then constituted, was compelled by the Acts of 1857 and 1858 to pay to the Corporation a compensation of £1,500,000 for the surrender of that right, the interest upon which sum must still be defrayed out of the dues and tolls levied upon the goods and shipping which enter this port; yet most undoubtedly was there a great advantage realised, inasmuch as this interest remaining stationary, the taxation upon goods or shipping for that purpose, must proportionately decrease as the trade of the port increases, or must ultimately cease altogether by payment of the principal.

Thus we see that a sum of £2,250, paid in seasonable time in order to enable this corporation, or its delegates, the dock committee, to develop the resources of the port with all freedom of action and with that hearty will which men display when they set to work improving their own property, was raised to 666 times its value after a period of 80 years; whereas, if it had been allowed to accumulate with compound interest, at the rate of five per cent. per annum, its value at the end of the same period of time would only have been

$$S = 2250 \times 2^{\frac{80 \times \log. 1{\cdot}03}{\log. 2}} = £111{,}420$$

or about fifty times its orginal value.

As the Lords Molyneux had only shortly before been raised to the dignity of earls of the realm, we are inclined to think that the then representative of that noble house consented to that sale rather from a desire to further the interests of the trade of the port than from any actual want of a paltry sum of £2,250 in hard cash, and on that ground we think that his lordship is entitled to an equal share, at least, of praise and gratitude at the hands of the mercantile community of Liverpool, as the managers of the corporate estate who conducted the negociations of that transaction.

Chronological Table of the Shipping belonging to the Ports of Liverpool and London.

Dates.	Liverpool.			London.	
	Ships.	Tonnage.	Dock Duties.	Ships.	Tonnage.
1540	12	177	...		...
1555	12	293	...		...
1665	15	259	...		...
1709	84	5,789	...		...
1716	113	8,386	...		...
1723	131	8,700	810 11 6		...
1730	412	18,070	...		...
1737	171	12,016	...		...
1744	181	13,775	...		...
1751	220	19,176	...		...
1760	1,245	...	2,330 6 7		...
1770	2,073	...	4,142 17 2		...
1790	4,223	...	10,037 6 2½		...
1801	5,060	459,719	28,365 8 2		1,150,000
1811	5,616	611,190	54,752 18 5		1,360,000
1820	7,276	805,033	94,412 11 10		1,540,062
1830	11,214	1,411,964	151,329 17 10		1,976,796
1840	15,998	2,445,708	178,186 14 0		2,390,544
1850	21,071	3,737,666	269,020 14 0		2,758,320
1860	21,136	4,697,238	397,315 12 11		...

These figures show that while the shipping belonging to the port of Liverpool has tenfolded itself since the beginning of this century, that belonging to the port of London has not trebled itself, and amply verify the assertion we have made in the course of our paper that the rate of development of the former port has been much greater than that of the latter.

Notwithstanding this, the amount of shipping which enters the port of London from foreign and colonial ports is still greatly in excess of that which enters the port of Liverpool, as may be seen from the following table:—

Table of Shipping which entered the Port of London.

Dates.	Foreign Ports.		British Possessions.		Total.	
	Ships.	Tonnage.	Ships.	Tonnage.	Ships.	Tonnage.
1854	8,576	1,838,700	2,367	829,123	10,943	2,667,823
1858	9,050	2,124,070	2,122	837,239	11,172	2,961,309
1862	9,237	2,344,043	2,418	1,003,037	11,655	3,347,080

Table of Shipping which entered the Port of Liverpool.

Dates.	Foreign Ports.		British Possessions.		Total.	
	Ships.	Tonnage.	Ships.	Tonnage.	Ships.	Tonnage.
1854	3,458	1,619,128	1,035	571,276	4,493	2,190,404
1858	3,618	1,714,251	894	606,083	4,512	2,320,334
1862	3,332	1,804,284	1,079	812,880	4,411	2,617,164

This table shows an excess of tonnage for the port of London of about one-fourth of that for Liverpool, but at the same time reveals the interesting and very important fact that the average burthen of ships entering the latter port is just double that of ships entering the port of London.

(*To be continued.*)

F. W. WYMER'S HIGH AND LOW PRESSURE ENGINES.

(*Illustrated by Plate* 263.)

The arrangement of engines we have illustrated in the accompanying Plate 263 has been designed and patented by Mr. F. W. Wymer, Newcastle-on-Tyne, Superintending Engineer to the Tyne and Continental Steam Navigation Company. We have previously had occasion to speak favourably of the performances of combined high and low pressure expansively-working engines,* and we are glad to find that the designers of marine engines are giving their attention to this class of engine, with a view to introduce improvements or modifications tending to facilitate their more general adoption. Mr. Wymer aims chiefly in his arrangement at giving increased accessibility to the several parts and in rendering the whole arrangement simple and compact.

The pair of inverted screw engines the subject of our plate are of 250 nominal horse-power. Fig. 1 being a side elevational view; Fig. 2, a plan; and Fig. 3, a sectional elevation, one half being taken through the large or expanding cylinder, and the other half being taken through the small or high pressure cylinder; the steam passes first into the small cylinder, and thence into the large cylinder, where it is expanded.

It will be seen that the two cylinders are supported by hollow columns or supports, one of which is adapted to serve as a condenser. The piston rods—there being two piston rods to each piston—of the two cylinders give motion to a beam or lever, which has its fulcrum or axis carried in bearings supported on one of the hollow supports or columns, the end of the beam beyond ts fulcrum or axis being provided with a counterpoise weight to balance parts of the machinery; the beam between the points where the piston-rods of the two cylinders are connected to it, gives motion by a connecting rod to the crank of the main or driving shaft, as shown in our plate.

The air and cold water pumps are worked direct from the crosshead of the expanding cylinder piston rods. The bilge and feed pumps being worked from crosshead of the high pressure cylinder piston rods.

We may add that instead of the arrangement of inverted cylinder engines which we have illustrated and described, Mr. Wymer proposes (when, as in case of war vessels, minimum height of engines above shaft is an object to be attained) to place the cylinders in a horizontal position. The condensers, crank framing and expanding cylinders forming the base of engine. The high pressure cylinder being placed above the expanding cylinder parallel to it. The beam in this case being suspended by its axis or fulcrum, carried in bearings on supports at side of the condenser, the engine requires no counter-balance weight to equalise the parts.

The crank-shaft in this case is placed between the cylinder and condenser, the piston-rods of high pressure cylinder passing over, and the piston-rods of expanding cylinder passing below the shaft, to the respective crossheads, connected to the beam by links, the connecting rod returning back from beam to crank. The air, cold water, and feed pumps are worked direct from the piston of expanding cylinder by the piston rod (from lower side of piston) and crosshead. The bilge pumps are worked by eccentrics on main shaft. In an engine so arranged, having 100in. expanding cylinders with 6ft. stroke, the space occupied athwart ship is under 15ft. on each side of centre of vessel.

* *Vide* the performance of the *Chile*, given in The Artizan of March last, and that of the *Peru* and other vessels fitted with double-cylinder expansion engines, by Messrs. Randolph, Elder, and Co., noticed in The Artizan volumes for 1859 and 1860.

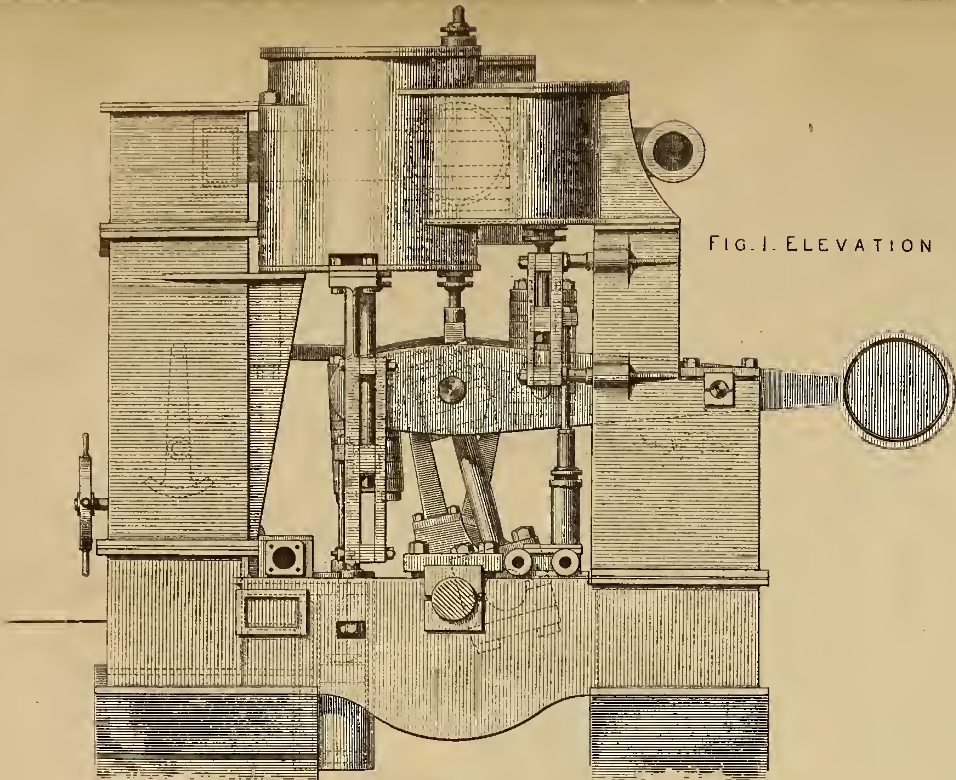
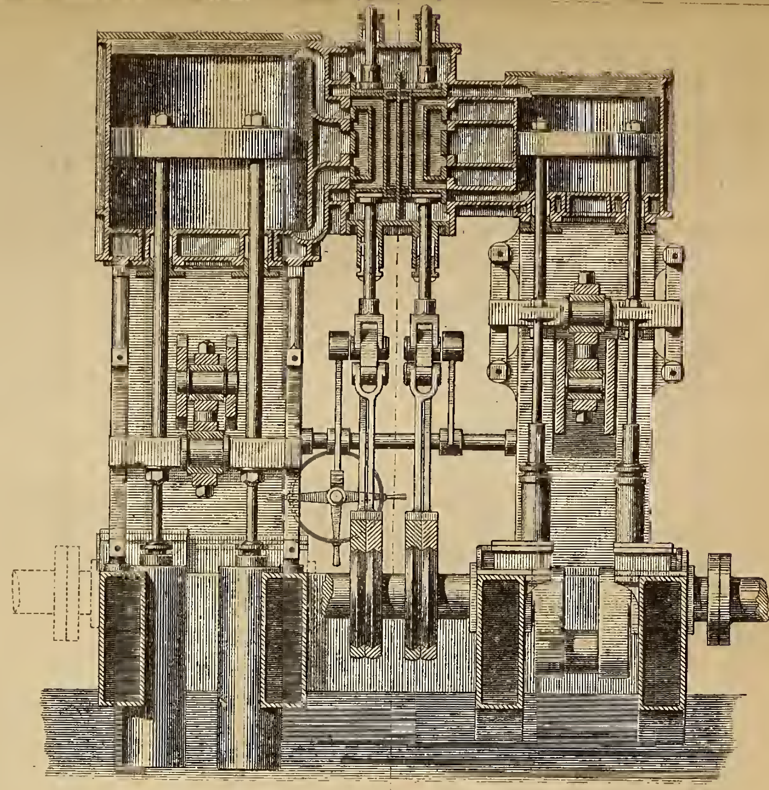


FIG. 1. ELEVATION



Section thro' Expanding Cylinder | Section thro' High Pressure Cylinder

FIG. 3.

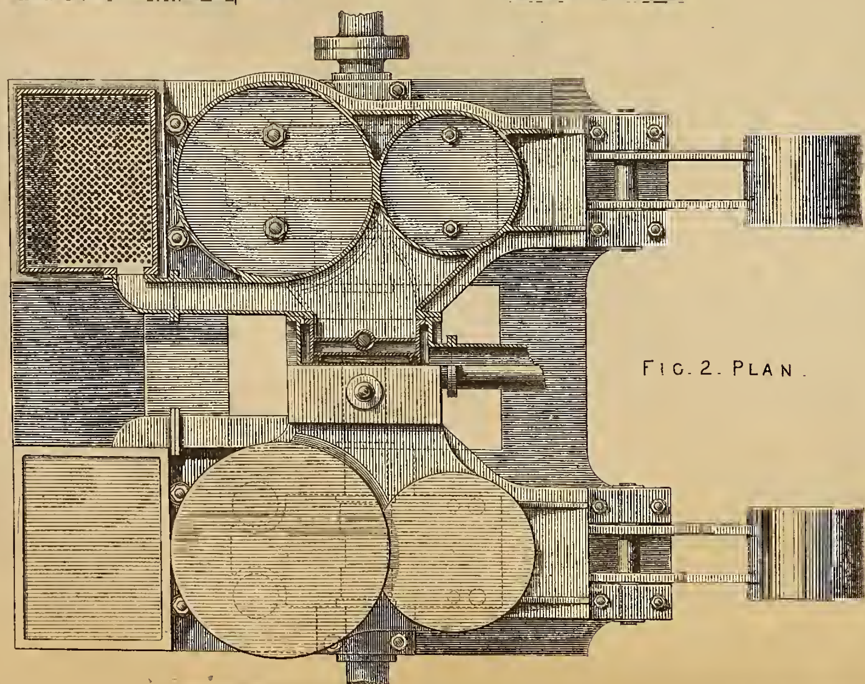


FIG. 2. PLAN.

250 HP INVERTED CYLINDER ENGINES,

DESIGNED BY

F. W. WYMER,

ENGINEER.

NEWCASTLE-ON-TYNE.

12 6 0 1 2 3 4 5 10 15

Scale of Feet

V Smith. C.E. direx

CUT-OFF VALVES.

A correspondent has asked us for a description of Mayer's valve. A paper was recently contributed to the "Journal of the Franklin Institute," by Mr. J. D. Van Buren, upon the modification of this description of valve, known in the United States as Merrick's valve; and as the information given by Mr. Van Buren, in the paper which has appeared in the "Journal of the Franklin Institute," is quite to the point, we make no apology for here reprinting it:—

The object sought in this paper is to obtain formulæ for designing the parts, and to discuss the circumstances of the motion of this valve, which is a momentarily adjustable *cut-off*. Fig. 1 shows an outline of a longitudinal section of the valve and its eccentrics. S S is the valve-seat; P P are the ports leading to the cylinder A A, E its exhaust passage; p p, steam ports of the main valve V V, and e its exhaust-port; l l are two small slides driven by an independent eccentric over the back of the main valve, and adjustable upon the stem by means of right and left hand screws and nuts; so that by turning the stem the valves can be made to approach or recede from each other, according to the degree of expansion required. C is the shaft with eccentrics attached. To simplify the sketch, the steam-chest, &c., are omitted. The action of the valve will be readily understood by reference to the figure. The steam can enter the cylinder only through the ports p p, and, by adjusting the valves l l, these ports can be closed at almost any point of the motion of the piston A A. It will be seen that the main valve is simply a modification of the ordinary three-ported locomotive slide. The valves l l are usually *roofed* over, and this roof or back connected with the condenser by means of a pipe and ring packing against the steam-chest bonnet, thus making the valve a *balanced* valve.

The following notation will be adopted in this discussion:—

R = length of crank of shaft.
r_1 = crank-arm or half throw of eccentric of main valve.
r = crank-arm or half throw of eccentric of cut-off valves l l.
c = cover or lap of main valve.
l = lead of main valve.
d = distance between outer edges of ports p and valves l when the main valve is in its central position.
v = length of faces of cut-off valves l l.
p = breadth of steam ports p p.
b = distance between inner edges of ports p p.
x = angle made by crank R with axis of cylinder at the instant when steam is cut off.
y = angle made by r_1 at same time, with same line.

Suppose now the crank is at B¹, or the piston at the top of its stroke. By following out the motion, it will be perceived that to make the arrangement effective as an adjustable cut-off, the eccentric of the valves l l must be set at 180° ahead of the crank R, provided no rock-shafts intervene between r r_1 and their respective valves. The eccentrics must be set 180° ahead of their proper position without rock-shafts, when rock-shafts are used. Let the eccentric rods be supposed to be always parallel to the axis of the cylinder. Then observing that the distances from the centre of the shaft to the edges of the port p and valve l are equal when the edges come together, we shall have for any angle x

$$L - r_1 \cos. y = L - r_1 \cos. \left(90^\circ + \sin.^{-1}\frac{c + l^{*}}{r_1} + x\right) = L' + r \cos. x \quad (1)$$

But

$$L + d = L' + r \cos. \sin.^{-1}\frac{c + l^{*}}{r_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)^1$$

and by substitution in (1)

$$d = r \cos. \sin.^{-1}\frac{c + l}{r_1} - r_1 \cos. \left(90^\circ + \sin.^{-1}\frac{c + l}{r_1} + x\right) - r \cos. x \quad (a)$$

or,

$$= \frac{r}{r_1}\sqrt{r_1^2 - (c + l)^2} - r_1 \cos. \left(90^\circ + \sin.^{-1}\frac{c + l}{r_1} + x\right) - r \cos. x \quad (2)$$

since $\sin. \sin.^{-1}\frac{c + l}{r^1} = \frac{c + l}{r_1}$, and $\cos. = \sqrt{1 - \sin.^2}$

or, since $-\cos. (90^\circ + a) = + \sin. a$.

$$d = \frac{r}{r_1}\sqrt{r_1^2 - (c + l)^2} + r_1 \sin. \left(\sin.^{-1}\frac{c + l^{\dagger}}{r_1} + x\right) - r \cos. x. \quad (2)^1$$

The arc $\sin.^{-1}\frac{c + l}{r_1}$ being that through which r_1 must move from its central position to give $c + l$.

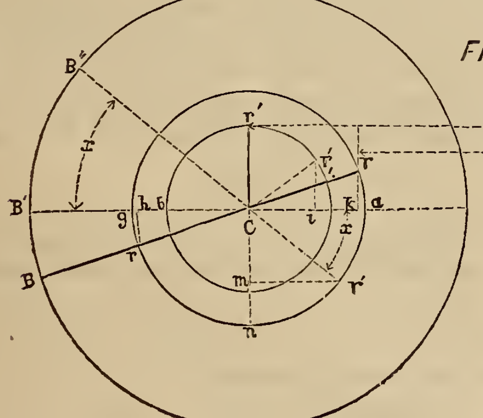
Formula (2)¹ therefore shows how far the edge of l must be from that of p when the main valve is in its central position, in order to cause a cutting off of the steam when the angle of the crank is x.

Again, suppose the arms r_1 and r to have moved to the positions c and d, Fig. 2, respectively; both valves will now be travelling in the same

* $\sin.^{-1} x$ means the arc or angle whose *sine is equal to x*, and similarly for $\cos.^{-1}$.

† L and L′ are the lengths of the eccentric-rods of r_1 and r respectively.

FIG. 1.



MAIN VALVE FOR CENTRAL POSITION.

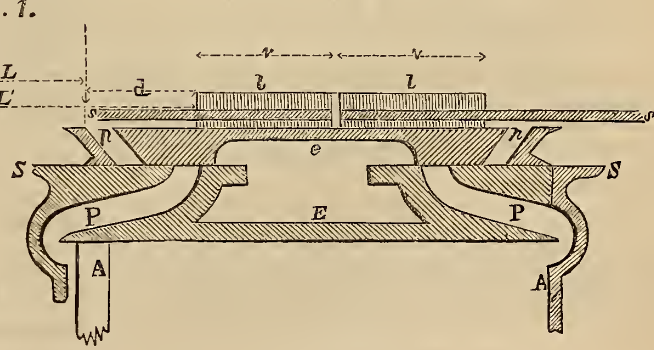


FIG. 1. Angle r C $a = \sin.^{-1}\frac{C + l}{r_1}$

$k\,h = 2\,r \cos. \sin.^{-1}\frac{C + l}{r_1}$

Angle $b\,C\,r^1{}_1 = 90^\circ + \sin.^{-1}\frac{C + l}{r_1} + x$

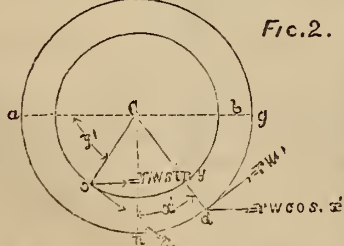
$C\,i = -\,r_1 \cos. y$

$r^1\,m = r \cos. x$

When edges of valves come together $L + C\,i = L' + m\,r'$ } Eq. (1) & (1′)
When main valve is in central position $L + d = L' + C\,k$ }

N.B.—All angles measured round from C B′.

FIG. 2.



direction, and if the velocities of the two valves are equal when the edges come together, then will the main valve get ahead of the cut-off valve, and the port p will again be opened if any further motion ensue (supposing, as we must, that l was behind p before the edges came together). Therefore, for that position of the crank, above half-stroke, which corresponds with equal velocities of the two valves, $l\ l$ are useless, and for all points beyond to the end of the stroke. The main valve must therefore be provided with sufficient lap to cut off the steam when the crank assumes this limiting position, and in practice the lap should be slightly greater than this amount.

To find this limiting position, refer to Fig. 2, and let w be the angular velocity of the shaft, then by the conditions,

$$r_1 w \sin. y_1 = r w \cos. x_1 \quad \ldots\ldots\ldots\ldots \quad (3)$$

But $y_1 = x - \left(90^\circ - \sin.^{-1}\dfrac{c+l}{r_1}\right) = x + \sin.^{-1}\dfrac{c+l}{r_1} - 90^\circ$ and $x^1 = x - 90^\circ$.

$$\therefore -r_1 \cos.\left(x + \sin.^{-1}\frac{c+l}{r_1}\right) = r \sin. x$$

and since $\cos.(a+b) = \cos. a \cos. b - \sin. a \sin. b$, generally.

$$\therefore -r_1 \cos. x \frac{\sqrt{r_1^2 - (c+l)^2}}{r_1} + r_1 \sin. x \frac{c+l}{r_1} = r \sin. x$$

$$\therefore \tan. x = \frac{\sqrt{r_1^2 - (c+l)^2}}{(c+l) - r} \quad \ldots\ldots\ldots\ldots \quad (4)$$

Therefore the main valve must have sufficient lap to cut off the steam when the crank makes an angle x, whose tangent

$$= \frac{\sqrt{r_1^2 - (c+l)^2}}{(c+l) - r}$$

with the axis of cylinder. The positive sign must be used for the radical, and the tangent will then be negative, showing the angle to be over 90°.

To find how much is necessary to accomplish this end, we have (see *Bourne's Treatise, Slide-valve*),

$$c = r_1\sqrt{\frac{2\,R - S''}{2\,R}} - \tfrac{1}{2}\,l \quad \ldots\ldots\ldots\ldots \quad (5)$$

where S″ is the distance of the piston from the end of the stroke when the steam is cut-off.

$$\therefore S'' = R\,(1 - \cos. x).$$

$$\therefore c = \text{lap} = r_1\sqrt{\frac{1 + \cos. x}{2}} - \tfrac{1}{2}\,l \ldots\ldots\ldots\ldots \quad (6)$$

and we must assume such a value to x in equation (6) that when c calculated by (6) is substituted in (4), the value of x found by (4) shall be slightly greater than the assumed value of x. This angle x is generally about 120°, and therefore one trial will generally fix how much lap (c) must be given in order that the main valve shall cut off before the cut-off valves begin to uncover the ports $p\ p$.

This maximum value of x substituted in equation (2) will give the maximum value of d required, and will therefore determine the length of the screw on the stem S S; and if $x = 0$, in equation (a), the value of d then obtained will be the proper distance between the edges of p and l, when the main valve is in its central position, necessary to cause the steam to be cut off when the piston is at the top of its stroke. A value

$$x = -\sin.^{-1}\frac{c+l}{r_1}$$

will give equation (a) $d = 0$, as it should.

To prevent the uncovering of the ports $p\ p$ at the inner edges, the faces of the valves $l\ l$ must have a length corresponding with the maximum separation of the edges after steam has been cut off, *i.e.*, l must equal the breadth of the port p plus the distance which the outer edge of l passes over the outer edge of p, when this distance is a maximum. Now, suppose the steam cut off when $x = 0$; it will be seen that the maximum value of d is the maximum distance to which the outer edge of l will attain beyond p, and therefore,

$$\text{Breadth of face} = v = d + p \quad \ldots\ldots\ldots\ldots \quad (7)$$

where d has its maximum value.

There, however, must be a corresponding distance between the inner edges of the ports $p\ p$ to accommodate all these conditions. Let a represent the distance between inner edges of valves $l\ l$, and suppose the main valve to be in its central position; then we shall have

$$2\,v + a + d = 2\,r \cos. \sin.^{-1}\frac{c+l}{r_1} + b + 2\,p - d \ldots\ldots \quad (8)$$

Since for the other end of the stroke the outer edges of the other cut-off valve and port p, must be in the same relative position as the two under discussion.

$$\therefore b = 2\,(v + d) - 2\,r \cos. \sin.^{-1}\frac{c+l}{r_1} - 2\,p + a \ \ldots\ldots \quad (9)$$

but we may make $a = 0$, when the valves are adjusted for a maximum value of x; also

$$v = d + p, \text{ and } r \cos. \sin.^{-1}\frac{c+l}{r_1} = \frac{r}{r_1}\sqrt{r_1^2 - (c+l)^2}$$

$$r \therefore b = 4\,d - \frac{2r}{r_1}\sqrt{r_1^2 - (c+l)^2} \quad \ldots\ldots\ldots\ldots \quad (10)$$

where d has its maximum value determined by the value of x in equation (4). Observe equation (8) that the valves $l\ l$ travel

$$2\,r \cos. \sin.^{-1}\frac{c+l}{r_1}$$

while the main valve passes from its central position around 180°.

Recapitulation.

$$d = \frac{r}{r_1}\sqrt{r_1^2 - (c+l)^2} + r_1 \sin.\left(\sin.^{-1}\frac{c+l}{r_1} + x\right) - r \cos. x \quad (11)$$

$$\left\{\begin{array}{ll} \tan. x = \sqrt{\dfrac{r_1^2 - (c+l)^2}{(c+l) - r}} & \ldots\ldots\ldots\ldots \quad (12) \\[2ex] c = r_1\sqrt{\dfrac{1 + \cos. x}{2}}\ \tfrac{1}{2}\,l & \ldots\ldots\ldots\ldots \quad (13) \end{array}\right.$$

$$v = d + p \quad \ldots\ldots\ldots\ldots \quad (14)$$

$$b = 4\,d - 2\,\frac{r}{r_1}\sqrt{r_1^2 - (c+l)^2} \ldots\ldots\ldots\ldots \quad (15)$$

The main valve is designed in the same manner as the common locomotive slide. It will be observed that r_1 must at least be equal to $d\ c + p$, in order that the port may be fully opened; and therefore $r_1 = c + p$ determines r_1. The lead is assumed, according to the judgment of the designer, but generally varies from $\frac{1}{16}$in. to $\frac{3}{8}$in. for engines with high velocities, the lead being greater than is required for engines with low velocities. This lead will of course depend somewhat upon the length of the port p and the capacity of the cylinder, but may safely be assumed between the above limits. If $r_1 = r$, the formulæ will be somewhat simplified.

Example.

Let $\quad r_1 = 5'', r = 5{\cdot}5'', l = 0{\cdot}2''.$

Now, assume that the cut-off valves are efficient only up to a value of $x = 120^\circ$, or for three-fourths the stroke of piston; therefore equation (13).

$$c = 5\sqrt{\frac{1 + \cos. 120^\circ}{2}} - \tfrac{1}{2}\,l = 5\sqrt{\frac{1 - \frac{1}{2}}{2}} - 0{\cdot}1'' = \tfrac{5}{2}'' - 0{\cdot}1 = 2{\cdot}4''$$

substituting this value of c in equation (12),

$$\therefore \tan. x = \frac{\sqrt{25 - 2{\cdot}6^2}}{2{\cdot}6 - 5{\cdot}5} = -\frac{\sqrt{18{\cdot}24}}{2{\cdot}9} = -1{\cdot}4727 = \tan. 124^\circ\ 11'$$

or by logarithms

$$\log. \tan. x = \log. -\sqrt{\frac{18{\cdot}24}{2{\cdot}9}} = -0{\cdot}1681144 = \log. \tan. 124^\circ\ 11''$$

Therefore this value of c is sufficient, and the main valves will cut off the steam before the limiting angle for $l\ l$ is attained—being 4° 11′ before the edges of the valve l come in contact with p, the steam-port of $v\ v$; d need not therefore be calculated for an angle greater than 120°.

$$\therefore (\text{eq. } 11)\ d = \frac{5{\cdot}5}{5} \times \sqrt{25 - 2{\cdot}6^2} + 5 \sin.\left(120^\circ + \sin.^{-1}\frac{2{\cdot}6}{5}\right) + 5{\cdot}5 \times \tfrac{1}{2}$$

$$d = 1{\cdot}1\sqrt{18{\cdot}24} + 5\ \text{siu.}\ (120^\circ + \text{siu.}^{-1}{\cdot}52) + 2{\cdot}75$$

But the arc whose sine is 0·52 = 31° 20′

$$\therefore d = 1{\cdot}1\sqrt{18{\cdot}24} + 5 \sin.(120° + 31° 20′) + 2{\cdot}75 = 4{\cdot}697 + 5 \sin. 28° 40′ + 2{\cdot}75$$

since $\sin.(180 - x) = \sin. x$.

$$\therefore d = 4{\cdot}697 + 5 \times 0{\cdot}47971 + 2{\cdot}75 = 9{\cdot}85''$$

But $$v = p + d = r_1 - c + d = 5 - 2{\cdot}4 + 9{\cdot}85 = 12{\cdot}45''$$

and $$b = 4\,d - \frac{2r}{r_1}\sqrt{r_1^2 - (c + l)^2} = 39{\cdot}40 - 9''{\cdot}394 = 30''{\cdot}016.$$

The length of the screws on the stem $f\,f$ must therefore be d + length of the nut.

Much of the arithmetical work above might have been omitted, but it is thought the method will be more readily comprehended by giving all the details of the computation.

The small valves are therefore efficient between the limits $x = 0$ and $x = 120°$, and the engine may be stopped by means of the expansion gear. By contracting these limits the ports may be made smaller. For instance, if it is not required to cut off the steam below one-fourth the stroke from commencement, *i.e.*, to expand the steam more than through three-fourths the stroke, the value of v may be diminished by the value d has for $x = 60°$; b will be diminished by twice the value d has for $x = 60°$.

The above dimensions are by no means meant for a criterion, since the assumptions must vary with the case and judgment of the designer; but are simply used as an illustration—although correct for the assumed conditions.

ROYAL INSTITUTION OF GREAT BRITAIN.

ON THE CHEMICAL HISTORY AND APPLICATION OF GUN-COTTON.

BY PROFESSOR ABEL, F.R.S., DIRECTOR OF THE CHEMICAL ESTABLISHMENT OF THE WAR DEPARTMENT.

The history of gun-cotton affords an interesting illustration of the facility with which the full development of a discovery may be retarded, if not altogether arrested for a time, by hasty attempts to apply it to practical purposes, before its nature has been sufficiently studied and determined.

When Schönbein, in the autumn of 1846, announced that he had discovered a new explosive compound, which he believed would prove a substitute for gunpowder, the statement attracted general attention, and attempts were made with little delay in different countries, to apply the material to purposes for which gunpowder hitherto had been alone used. Schönbein and Böttger (who appear to have discovered gun-cotton independently, shortly after the former had produced it), lost little time in submitting their discovery to the German Confederation; and a committee was appointed for its investigation, by whom gun-cotton was eventually pronounced inapplicable as a substitute for gunpowder.

In this country gun-cotton was experimented with immediately after the method of its preparation was published by Schönbein. Researches were instituted into its nature, preparation, &c., by Porrett and Teschemacher, John Taylor, Gladstone, and others. A few experiments were made on its application as a propelling and mining agent, and the manufacture of the material upon a considerable scale was set on foot by Messrs. Hall, the well-known gunpowder makers at Faversham; a patent having been previously taken out in this country for the production of gun-cotton according to Schönbein's process. This factory had, however, not been long in operation before a very disastrous explosion occurred at the works, by which a number of men lost their lives, and which was ascribed to the spontaneous ignition of the gun-cotton, by the jury who endeavoured to investigate its cause. From that time, the manufacture of gun-cotton upon any considerable scale was abandoned in England, and no important contributions to our knowledge of this material was made until, in 1854, Hadow published the results of some valuable investigations, which served to furnish a far more definite knowledge regarding the true constitution and proper method of producing gun-cotton, than had hitherto existed.

In France, gun-cotton was also made the subject of experiments as early as the winter of 1846; and its manufacture was carried on at the Government powder-works at Bouchet, near Paris. Some interesting balistic experiments were instituted, under the direction of Piobert, Morin, and other men of eminence, with gun-cotton, in comparison with different kinds of gunpowder, the results of which indicated, that, for producing equal effects to those furnished by a given weight of gun-cotton, it was necessary to employ a double quantity of sporting powder, three times the quantity of musket-powder, and four times the weight of cannon-powder. It was also found that the best results appeared to be obtained by arranging the gun-cotton so that it should occupy the same space as the charge of gunpowder required to produce an equal effect; and other data were arrived at, which show that the investigators were being led to work in a direction similar to that afterwards so successfully pursued by Baron von Lenk, Austria. Unfortunately, however, disastrous explosions occurred at the works at Bouchet; one as early as March, 1847, in a drying chamber; and two, following closely upon each other, in 1848. One of these took place in a magazine, near which it was believed nobody had been for several days; the other occurred also in a magazine where gun-cotton was being packed; and on this occasion several lives were lost. These disasters appear to have put an end, until quite recently, to experiments with gun-cotton in France.

After the material had been pronounced upon unfavourably by the committee of the German Confederation, one of its members, Baron von Lenk, continued to devote himself to its study, and with such success, it appears, that a committee was eventually appointed by the Austrian Government in 1852, to inquire fully into the merits of the material. A sum of money was paid to Schönbein and Böttger, in recognition of the value of their discovery; and an experimental manufactory of gun-cotton was established at the Castle of Hirtenberg, near Vienna. A particular form of gun was devised by Baron von Lenk, for employment with gun-cotton, of which a 12-pounder battery was established. The performances of these guns were considered sufficiently satisfactory to warrant the preparation of four more batteries, which were sent to the army of observation in Galicia in 1855, but did not go into active service. It appears that, in consequence of a want of uniformity in the effects of the gun-cotton, and of an injurious effect upon the guns, added probably to the prejudice entertained against it by the artillery corps, the material fell into disfavour, and its application to cannon was for a time abandoned.

It was received, however, with much greater favour by the engineers, and was applied with great success to mining and submarine operations. Meanwhile, Baron von Lenk's labours to perfect gun-cotton as a material for artillery purposes were unceasing, and, at the close of the Italian war, the subject of its application was again thoroughly reopened at the instigation of Count Degenfeld, then minister of war, who had, at an earlier period, taken an active interest in Baron von Lenk's investigations. After upwards of one year's experiments, a system of rifled field and mountain guns, to be employed with gun-cotton, which had been elaborated by von Lenk, was introduced into the Austrian service; thirty batteries of these guns were equipped, and it was considered as definitely settled that gun-cotton would before long be introduced into the service in the place of gunpowder for artillery purposes.

In 1862, however, an explosion occurred in a magazine at Simmering, near Vienna, where both gunpowder and gun-cotton were stored; and this disaster appears to have fortified to such an extent the arguments which were adduced against the employment of gun-cotton, by its opponents in the artillery service, that its use in this direction was again put a stop to for a time. Ultimately, a committee of investigation was appointed, which consisted in part of eminent scientific men, and which appears, after careful deliberation, to have reported highly in favour of the stability and important properties, as an explosive, of the material, a report, which was supported by the favourable opinion entertained of gun-cotton by the Austrian engineers, in whose name Baron von Ebner prepared a very complete and interesting account of the properties and effects of the agent, with particular reference to mining and other engineering operations.

Gun-cotton appears, therefore, to have been again restored to favour in Austria, but no official accounts have reached England, up to the present time, with regard to its employment in the recent war operations in that country.

In the spring of 1862, full details relating to the manufacture and modes of applying gun-cotton were communicated by the Austrian Government to that of Her Majesty, and the War Office chemist was at once instructed to institute experiments upon the manufacture of gun-cotton, and upon its chemical constitution and stability. In the autumn of that year, General Sabine directed the attention of the British Association to the result obtained with gun-cotton in Austria; and a combined committee of engineers and chemists was appointed to inquire into the subject. At the meeting of the association in 1863, this committee presented a report, which was based upon information received partly from General von Lenk, who had been permitted by the Austrian Government to visit this country for the purpose of communicating fully with the British Association on the subject, and partly upon the results already arrived at in the experiments instituted by the lecturer, under the direction of the Secretary of State for War. Subsequently, a committee of investigation was appointed by the latter, under the presidency of General Sabine, composed of scientific men connected with the Royal Society and British Association, and of military and naval officers of considerable experience; and this committee has been entrusted with the full investigation of the properties of gun-cotton, as improved by Baron von Lenk, with reference to its application to military, naval, engineering, and industrial purposes.

The chemical constitution of gun-cotton, concerning which the opinions of chemists were divided until 1854, has been conclusively established by the researches of Hadow. In the formation of substitution-products, by the action of nitric acid upon cotton or cellulose, three atoms of the latter appear to enter together into the chemical change, and the number of atoms of hydrogen replaced by peroxide of nitrogen in the treble atom of cellulose, $C_{18}\,H_{30}\,O_{15} = 3\,(C_6\,H_{10}\,O_5)$, may be nine, eight, seven, or six, according to the degree of concentration of the nitric acid employed.

The highest of these substitution-products is trinitrocellulose, pyroxilin, or gun-cotton; $C_{18} \left\{ \begin{matrix} H_{21} \\ 9\,N\,O_2 \end{matrix} \right\} O_{15} = 3\,C_6 \left\{ \begin{matrix} H_7 \\ 3\,N\,O_2 \end{matrix} \right\} O_5$; this being the substance first produced by Pelouze in an impure condition, in 1836, by the action of very concentrated nitric acid upon paper, or fabrics of cotton or linen; and afterwards obtained in a purer form by Schönbein, who employed a mixture of concentrated nitric and sulphuric acids for the treatment of cotton-wool, the object of the sulphuric acid being to abstract water of hydration from the nitric acid and also to prevent the action of the nitric acid from being interfered with by the water which is produced, as the chemical transformation of the cotton into gun-cotton proceeds. The formation of trinitrocellulose is represented by the following equation:—

$$\underbrace{C_6\,H_{10}\,O_5}_{\textit{Cotton.}} + \underbrace{3 \left\{ \begin{matrix} H \\ N\,O_2 \end{matrix} \right\} O}_{\textit{Nitric acid.}} = \underbrace{C_6 \left\{ \begin{matrix} H_7 \\ 3\,N\,O_2 \end{matrix} \right\} O_5}_{\textit{Gun-cotton.}} + \underbrace{3\,\left. \begin{matrix} H \\ H \end{matrix} \right\} O}_{\textit{Water.}}$$

The lowest substitution-product from cotton, of those named above, appears to

have the same composition as the substance which Braconnet first obtained in 1832, by dissolving starch in cold concentrated nitric acid, and adding water to the solution, when a white, highly combustible substance is precipitated, to which the name of *Xyloïdin* was given. The substitution-products from cotton, intermediate between the lowest and highest, are soluble in mixtures of ether and alcohol, and furnish by their solution the important material *collodion*, so invaluable in connection with photography, surgery, experimental electricity, &c.

According to Schönbein's original perscription, the cotton was to be saturated with a mixture of one part of nitric acid (of specific gravity 1·5) and three parts of sulphuric acid (sp. gr. 1·85), and allowed to stand for one hour. In operating upon a small scale, the treatment of cotton with the acid for that period is quite sufficient to effect its complete conversion into the most explosive product, *pyroxilin* or *trinitrocellulose*; but when the quantity of cotton treated at one time is considerable, especially if it be not very loose and open, its complete conversion into pyroxilin is not effected with certainty, unless it be allowed to remain in the acids for several hours. This accounts in great measure for the want of uniformity observed in the composition of gun-cotton, and its effects as an explosive in the earlier experiments instituted; and it is, moreover, very possible, that the want of stability, and, consequently, even some of the accidents, which it was considered could only be ascribed to the spontaneous ignition of the material, might have been due to the comparatively unstable character of the lower products of substitution, some of which existed in the imperfectly prepared gun-cotton.

The system of manufacture of gun-cotton elaborated by General von Lenk is founded upon that described by Schönbein; the improvements which the former has adopted, all contribute importantly to the production of a thoroughly uniform and pure gun-cotton; there is only one step in his process which is certainly not essential, and about the possible utility of which chemical authorities are decidedly at variance with General von Lenk.

The following is an outline of the process of manufacture of gun-cotton as practised by Lenk. The cotton, in the form of loose yarn of different sizes made up into hanks, is purified from certain foreign vegetable substances by treatment for a brief period with a weak solution of potashes, and subsequent washing. It is then suspended in a well-ventilated hot-air chamber until all moisture has been expelled, when it is transferred to air-tight boxes or jars, and at once removed to the dipping tank, or vessel where its saturation with the mixed acids is effected. The acids, of the specific gravity prescribed by Schönbein, are very intimately mixed, in a suitable apparatus, in the proportion originally indicated by that chemist, *i.e.*, three parts by weight of sulphuric acid to one of nitric acid. The mixture is always prepared some time before it is required, in order that it may become perfectly cool. The cotton is immersed in a bath of the mixed acids, one skein at a time, and stirred about for a few minutes until it has become thoroughly saturated with the acids; it is then transferred to a shelf in this dipping trough, where it is allowed to drain, and slightly pressed, to remove any large excess of acid; and is afterwards placed in an earthenware jar, provided with a tight-fitting lid (which receives six or eight skeins, weighing from two to four ounces each). The cotton is tightly pressed down in the jar, and, if there be not sufficient acid present just to cover the mass, a little more is added; the proportion of acid to be left in contact with the cotton being about 10½ pounds to one pound of the latter. The charged jars are set aside for forty-eight hours in a cool place, where, moreover, they are kept surrounded by water, to prevent the occurrence of any elevation of temperature and consequent destructive action of the acids upon the gun-cotton. The same precaution is also taken with the dipping-trough, as considerable heat is generated during the first saturation of the cotton with the acids. At the expiration of forty-eight hours, the gun-cotton is transferred from the jars to a centrifugal machine, by the aid of which the excess of acid is removed as perfectly as is possible by mechanical means, the gun-cotton being afterwards only slightly moist to the touch. The skeins are then immersed singly into water, and moved about briskly, so as to become completely saturated with it as quickly as possible. This result is best accomplished by plunging the skeins under a fall of water, so that they become at once thoroughly drenched. If they are simply thrown into water and allowed to remain at rest, the heat produced by the union of a portion of the free acids with a little water would be so great as to establish at once a destructive action upon the gun-cotton by the acid present. The washing of the separate skeins is continued until no acidity can be detected in them by the taste; they are then arranged in frames or crates and immersed in a rapid stream of water, where they remain undisturbed for two or three weeks. They are afterwards washed by hand, to free them from mechanical impurities derived from the stream, and are immersed for a short time in a dilute boiling solution of potashes. After this treatment they are returned to the stream, where they again remain for several days. Upon their removal they are once more washed by hand, with soap if necessary; the pure gun-cotton then only requires drying, by sufficient exposure to air at a temperature of about 27° C., to render it ready for use. A supplementary process is, however, adopted by General von Lenk, about the possible advantage or use of which his opinion is not shared by others, as already stated. This treatment consists in immersing the air-dried gun-cotton in a moderately strong hot solution of soluble glass (silicate of potassa or soda), for a sufficient period to allow it to become completely impregnated; removing the excess of liquid by means of the centrifugal machine; thoroughly drying the gun-cotton, thus "silicated," and finally washing it once more for some time, until all alkali is abstracted. Lenk considers that, by this treatment, some silica becomes deposited within the fibre of the gun-cotton, which, on the one hand, assists in moderating the rapidity with which the material burns, and, on the other hand, exercises (in some not very evident manner) a preservative effect upon the gun-cotton, rendering it less prone to undergo even slight changes by keeping. The mineral matter contained in pure gun-cotton which has not been submitted to this particular treatment amounts to about one per cent. The proportion found in specimens which have been "silicated" in Austria and in this country, according to Lenk's directions, varies between 1·5 and 2 per cent. It is difficult to understand how the addition of one per cent. to the mineral matter, in the form chiefly of silicates of lime and magnesia (the bases being derived from the water used in the final washing), which are deposited upon and between the fibres, in a pulverulent form, can influence, to any material extent, either the rate of combustion or the keeping qualities of the product obtained by Lenk's system of manufacture.

Gun-cotton prepared according to the system just described is exceedingly uniform in composition. The analyses of samples prepared both in Austria and at Waltham Abbey have furnished results corresponding accurately to those required by the formula $C_6 \left\{ \begin{matrix} H_7 \\ 3\,NO_2 \end{matrix} \right\} O_5$. In its ordinary air-dry condition it contains, very uniformly, about two per cent. of moisture; an amount which it absorbs again rapidly from the air, when it has been dried. The proportion of water existing in the purified air-dried cotton, before conversion, is generally about six per cent. When pure gun-cotton is exposed to a very moist atmosphere, or kept in a damp locality, it will absorb as much as from six to seven per cent.; but, if it be then exposed to air of average dryness, it very speedily parts with all but the two per cent. of moisture which it contains in its normal condition. It may be preserved in a damp or wet state apparently for an indefinite period without injury; for, if afterwards dried by exposure to air, it exhibits no signs of change.

In these respects it possesses important advantages over gunpowder. The normal proportion of hygroscopic moisture in that substance varies between three quarters and one per cent.; but if exposed in any way to the influence of a moist atmosphere, it continues to absorb water until, however firm the grains may have originally been, it becomes quite pasty. It need scarcely be stated that, when once gunpowder has become damp, it can no longer be restored to a serviceable condition, except by being again submitted to the processes of manufacture, starting almost from the commencement.

Perhaps the most vital consideration, bearing upon the possibility of applying gun-cotton to important practical purposes, are those which relate to the risk likely to be incurred in its manufacture, and preservation in large quantities. The manufacture of gun-cotton is unquestionably much safer than that of gunpowder; in fact, there is no possibility of accident until the final drying process is reached; as, in all the other stages, the material is always wet, and therefore harmless. With the adoption of a proper system of warming and ventilation, in the drying-chamber, the last operation is certainly not a more dangerous one than that of drying gunpowder. The question of the safe preservation of gun-cotton cannot as yet be so easily and satisfactorily disposed of. Specimens of gun-cotton exist, which were prepared according to Schönbein's directions in 1846, and which have undergone no change whatever; on the other hand, it is well known that gun-cotton, which was believed to have been perfectly purified, has become extremely acid and has even undergone so complete a decomposition, as to have become converted into oxalic acid and other organic products, when preserved in closed vessels, and especially when exposed continually, or occasionally, to light. This susceptibility to chemical change has been particularly observed in samples of gun-cotton known to consist chiefly, or to contain some proportion, of the less explosive or lower substitution-products (*i.e.* gun-cotton specially prepared for the manufacture of collodion). Hence, it is very possible that such instances as are considered to have been well authenticated, of the spontaneous ignition of gun-cotton, when stored in considerable quantities, or during exposure to very moderate heat, may have arisen not simply from an imperfect purification of the material, but also from the more or less imperfect conversion of cotton into the most explosive and apparently most stable product.

There is no doubt that the improvements effected in the system of manufacture of gun-cotton have been instrumental in rendering it far more stable in character than it was in the early days of its production upon a considerable scale. At the same time, although General von Lenk and its warmest partisans consider that its unchangeability can no longer be disputed, a greater amount of experience, combined with more searching investigations than have hitherto been instituted, upon the possibility of its undergoing change when under the influence of moderate heat, alone or combined with that of moisture, and when preserved under a variety of other conditions, are unquestionably indispensable before its claims to perfect permanence can be considered as properly established. It has already been ascertained by very recent experiments of the lecturer, that gun-cotton, prepared and purified with the most scrupulous care, speedily undergoes some amount of decomposition when exposed to temperatures ranging from 32° to 66° C.; it remains to be seen whether such decomposition, if once established by exposure of gun-cotton to some temperature within the above limits, will cease permanently, when the material is removed from the influence of heat; or whether precautions or efficient supplementary processes can be adopted in the manufacture, to counteract the tendency to change exhibited by gun-cotton under the above circumstances. These are only some of the points which need patient investigation before it is positively known whether the requisite confidence can be placed in the material, as an agent susceptible of substitution for gunpowder.

It has been ingeniously argued that a slight indication of spontaneous change in gun-cotton need give rise to no alarm, because gunpowder is also liable to slight spontaneous change, reference being made to the fact that a very minute proportion of the sulphur in that material has been noticed to undergo oxidation. It need hardly be stated that such a minute change cannot have the slightest effect upon the stability of the mechanical mixture, gunpowder, in which variations, as regards purity and proportions of ingredients, occur, to an extent which render this change of absolute insignificance; whereas, in the case of gun-cotton as now manufactured, the development of acid, however minute the proportion, may very possibly give rise to an important disturbance of chemical equilibrium, in a compound, the stability of which is based upon the perfect uniformity of its composition; and it may also be at once productive of

further change, by the tendency which the acid itself has to exert chemical action upon certain elements of the gun-cotton.

The general properties of gun-cotton as an explosive agent have long been popularly known to be as follows: when inflamed or raised to a temperature ranging between 137° and 150° C., it burns with a bright flash and large body of flame, unaccompanied by smoke, and leaves no appreciable residue. It is far more readily inflamed by percussion than gunpowder; the compression of any particular portion of a mass of loose gun-cotton between rigid surfaces will prevent that part from burning when heat is applied. The products of combustion of gun-cotton, in air, redden litmus paper powerfully; they contain a considerable proportion of nitric oxide, and act rapidly and corrosively upon iron and gun-metal. The explosion of gun-cotton, when in the loose, carded condition, the form in which it was always prepared in the early days of its discovery, resembles that of the fulminates in its violence and instantaneous character; in the open air it may be inflamed when in actual contact with gunpowder, without igniting the latter; in a confined space, as in a shell or the barrel of a gun, the almost instantaneous rapidity of its explosion, when in this form, produces effects which are highly destructive as compared with those of gunpowder, while the projectile force exerted by it is comparatively small.

Many attempts have been made from time to time to diminish the rapidity of explosion of gun-cotton; but the only one attended by any success is that which, in General von Lenk's hands, has led to the development of a system of mechanical arrangement of gun-cotton, as ingenious and simple as it is effective. By manufacturing the cotton into yarn, of different thicknesses and degrees of compactness or fineness of twist, before its conversion into gun-cotton, this material is at once obtained in forms which not only burn with great regularity and much less rapidity, when used in the original condition, than the loose gun-cotton wool, but which also, when employed in the form of reels, wound more or less compactly, or when converted into plaits or hollow ropes, may be made to burn gradually, in a manner similar to gunpowder, or to flash into flame instantaneously, exerting an explosive action very far exceeding that of the latter. The modifications in the nature and degree of explosive force exerted by gun-cotton, which are essential for its application to military and industrial purposes as a substitute for powder are, therefore, arrived at by means of very simple variations of the mechanical condition of the material. Thus, to obtain the gradual action essential for the employment of gun-cotton in cannon, cartridges are made up of coarse yarn, which is wound firmly round a hollow cylinder of wood, of dimensions regulated by the size of the gun-chamber and the weight of the charge used, the best result being obtained by so arranging the latter that the cartridge entirely fills the space allotted to the charge in the gun. Similarly, small-arm cartridges are made of cylindrical plaits of fine yarn or thread, which are fitted compactly in layers, one over the other, upon a small cylinder or spindle of wood. In both of these arrangements the combustion of the charge can proceed only from the external surfaces towards the interior of the cartridge. On the other hand, the charges for shells, in which the most rapid explosion is most effective; and the priming for quick matches which are intended for firing several charges simultaneously and almost immediately upon the application of flame, consist of cylindrical, hollow, and moderately compact plaits (similar to lamp-wicks) made of gun-cotton-thread, or very fine yarn. These plaits are produced in pieces of any length, and when employed as quick-matches are compactly enclosed in cases of waterproof canvas or other similar materials. The charges to be used in mines, in which the most destructive effects are aimed at, consist of pieces of very firmly-twisted rope, with a hollow core along the centre, the number of strands of which it is composed varying with the size of the charge to be used. For quarrying and blasting purposes, small lengths of the rope are employed singly; for military operations (demolition of works, &c.), it is packed into moderately stout cases of sheet-metal. In these hollow ropes and plaits of gun-cotton, the flame produced by the burning of that portion to which heat is applied, penetrates at once to the interior and into the interstices of the charge, and hence the entire mass of gun-cotton is converted into gas and vapour, with almost instantaneous rapidity. A striking illustration of the very opposite effects which can be produced by very simple modifications in the mechanical arrangement of the gun-cotton is afforded by the following experiment: if two or three strands of gun-cotton-yarn be very loosely twisted together and inserted into a tube of glass, or other material, in which they fit so loosely as to be readily drawn backwards and forwards, upon applying heat to a projecting portion at one end of the tube, the gun-cotton thus arranged will explode with great violence, completely pulverising the tube, if it be of glass; and the combustion will take place with such almost instantaneous rapidity that small portions of unburnt gun-cotton will actually be scattered by the explosion. But when two or more strands of the same gun-cotton yarn are tightly twisted, singly in the first instance, then made up into a firm cord, solid throughout, and enclosed in a glass tube or some other description of case into which the cord fits very tightly, if a protruding end of the gun-cotton be then inflamed the cord will burn with moderate rapidity until the fire reaches the opening of the case, when the combustion will pass over from the ordinary kind to a form which can only be described as a smouldering; the lighted extremity of the gun cotton simply glows within the case, while a steady jet of flame (furnished by the combustible gases evolved from the gun-cotton) continues to burn at the open extremity of the case, until the contents of the latter are consumed. The gun-cotton not only burns extremely slowly under these conditions, but also with the greatest regularity, so that the rate of combustion of a given length of the enclosed cord may be accurately timed. The rapidity of combustion of gun-cotton arranged in this given form may be regulated by the number of strands in a cord, and the degree of their compactness, and it is by this new modification of General von Lenk's system of arranging gun-cotton that the lecturer has succeeded in applying this material to the production of slow-matches and time-fuzes; uses for which it had not previously been found suitable.

Reference has just been made to inflammable gases evolved by gun-cotton while it undergoes a very slow combustion. The composition of gun-cotton renders it self-evident that, under any circumstances, the explosion of this substance must be accompanied by the production of a very considerable proportion of carbonic oxide. The large body of flame, always observed when gun-cotton is ignited under ordinary circumstances, is principally due to the combustion of carbonic oxide, and, probably also, of small quantities of carbo-hydrogen compounds, which, together with minute suspended particles of the mineral matter contained in the gun-cotton, give to the flame its brightness. If a tuft of gun-cotton be ignited in a capacious and somewhat deep vessel, the flame actually resulting from the burning of the tufts may be distinctly seen surrounded by a large body of flame, produced by the burning gases, which continue apparent for a very appreciable time after the disappearance of the flash of flame furnished by the explosion of the gun-cotton. If similar tufts be ignited in atmospheres of hydrogen, nitrogen, carbonic acid, coal gas, &c., the combustion of the gun-cotton is only accompanied by a very small and pale flame, of instantaneous duration. Similarly, if gun-cotton be ignited in a vessel which has been previously exhausted, to at any rate one-half the ordinary atmospheric pressure, the proportion of air, and therefore oxygen, present when the gun-cotton is ignited does not suffice to effect the combustion of any large proportion of the inflammable gases generated, and hence the explosion of the gun-cotton is attended only by a small pale flame. If, however, the vessel be filled with oxygen and then exhausted to an equal or even lower degree, it is filled with flame of dazzling brightness directly the ignition of the gun-cotton is effected.

The one modification just referred to, of the phenomena which attend the ignition of gun-cotton in a rarefied atmosphere, is not the only result observed in experiments of this kind. Various curious effects may be obtained; their nature being determined by the degree of rarefaction of the atmosphere, the mechanical condition of the gun-cotton, its position with reference to the source of heat employed, and other variable elements in the experiments. A brief account of some of the principal of these phenomena may not be without interest.

In the experiments with a tuft of gun-cotton in rarefied air, spoken of just now, a perceptible interval is observed between the first application of heat (by passage of a voltaic current through a platinum wire enclosed in the tuft) and the first appearance of ignition of the gun-cotton; moreover, the pale flame observed when the latter does burn, is of very perceptibly longer duration than that of the bright flash which attends the explosion of gun-cotton in air, under ordinary conditions. If instead of using the gun-cotton in the form of a tuft, a short piece of the gun-cotton yarn be employed in the experiment, and laid on a support so that it rests upon the wire by which it is to be ignited, the pale flame of the burning gun-cotton will travel along towards the two extremities of the piece of yarn with a degree of slowness corresponding to the extent of rarefaction of the atmosphere. These results are in perfect accordance with the observation (first made by Quartermaster Mitchell, afterwards fully examined into by Frankland, and recently amplified by Dufour), that the rate of burning of time-fuzes is influenced by the altitude at which they are burned, or, in other words, by the degree of pressure of the atmosphere, the combustion being proportionately slow with every decrement of pressure of the air. When the platinum wire is first raised to a red heat, in the centre of the tuft of gun-cotton enclosed in a highly rarefied atmosphere, the products resulting from the decomposition of that portion of the material which is in close contact with the wire, immediately distribute themselves through the rarefied space, conveying away, and rendering latent by their great expansion, the heat furnished by the platinum wire and that which results from the chemical change. The increase of pressure within the confined space, by the generation of the gases and vapours, on the one hand, and, on the other hand, the effect of the heated gases, which escape, upon the particles of gun-cotton through which they permeate, result, in the course of time, in the ignition of the mass; but even then the gun-cotton burns only slowly, because, in consequence of the rapidity with which the resulting gases and vapours escape and expand, much of the heat essential for the maintenance of the combustion is at once conveyed away. The latter result is strikingly exemplified by an experiment in which gun-cotton yarn is substituted for the tuft of carded gun-cotton; indeed, if the atmosphere be very highly rarefied (to 0·6 in inches of mercury) and a sufficient length of the gun-cotton yarn (4 or 5 inches) be employed in the experiment, the burning of the material, induced by the heated wire, will proceed so slowly, that the heat resulting from the chemical change will be conveyed away from the burning surface, by the gases generated, much more rapidly than it is developed, so that the gun-cotton will actually become extinguished when only a small portion of it has been burned.

A very similar result is obtained if gunpowder, either in the form of grains or of one large mass, is exposed to the action of an incandescent platinum wire imbedded in it, the pressure of the atmosphere, in the apparatus in which the experiment is made, being reduced to between 0·6 and 2, in inches of mercury. The portion of gunpowder contiguous to the heated wire will fuse; vapours of sulphur will be evolved in the first instance, and, subsequently, the charcoal will be oxidised by the nitre, bubbles of gas escaping from the fused mass. The vapours and gases thus generated convey away rapidly the heat provided by the wire and developed by the chemical action; and at the same time the change which the gunpowder undergoes diminishes its explosive character, so that its partial ignition or explosion will only be effected after the lapse of several minutes, and, if it be in the form of grains, the explosion of the particles contiguous to the wire will have the effect of scattering the remainder without igniting it.

The great reduction in the rapidity of combustion of gun-cotton is not the only result observed when small quantities of that substance are exposed to heat under diminished atmospheric pressure. In the most highly-rarefied atmospheres (from 0·5 to 1in.), the only indication afforded of the burning of the gun-cotton is the appearance of a beautiful green glow, like a phosphorescence, immediately surrounding that part which is undergoing decomposition. When the pressure of the atmosphere is slightly increased, a faint yellow lambent flame appears,

beyond the green glow, at a short distance from the point of decomposition; and in proportion as the atmosphere is less rarefied, this pale yellow flame increases in volume, while the green phosphorescence becomes less and less apparent until it seems to be completely obliterated. Lastly, when the pressure of the atmosphere is comparatively great (= 25 or 26, in inches of mercury), the gun-cotton burns with the ordinary bright flame, though less rapidly, of course, than it does under normal conditions of atmospheric pressure. There is no doubt that this bright flame is due to almost instantaneous secondary combustion (in the oxygen supplied by the air in the apparatus) of the inflammable gases evolved by the decomposition. On the other hand the production of the small pale flame, observed when gun-cotton is burned in more highly rarefied air, or in atmospheres of gases which cannot supply oxygen for combustion, is most probably due to the generation of a mixture of gases (by the change which gun-cotton undergoes under these conditions) which contains not only combustible bodies such as carbonic oxide, but also a proportion of oxidising gases (protoxide of nitrogen or even oxygen); such a mixture, having self-combustible properties, will receive sufficient heat from the burning gun-cotton to become ignited, except when the atmosphere in which the change takes place is so highly rarefied that the heat is immediately dissipated and the gases evolved become highly attenuated, as already described.

It will be readily conceived that the mechanical state of the gun-cotton (*i. e.*, the particular form in which it is employed), like other variable conditions which have been alluded to, will greatly influence the nature of phenomena observed, when this substance is ignited in air, or in various gases, either at ordinary or diminished pressures. This may be exemplified by the following experimental illustrations. It has been stated that when a tuft of carded gun-cotton is ignited in carbonic acid, carbonic oxide, nitrogen, coal gas, hydrogen, and other gases, it burns only with a pale yellow flame; this flame, when furnished by equal quantities of gun-cotton, is much smaller in an atmosphere of hydrogen than it is, for example, in carbonic acid; a fact which must be ascribed to the comparatively very rapid diffusion of the generated gases when hydrogen is used. In operating with pieces of gun-cotton yarn, instead of employing loose tufts, the material, when ignited by a red-hot wire in atmosphere of carbonic acid, nitrogen in carbonic oxide, burns much more slowly than it does in air under the same conditions; and its combustion is accompanied only by a very small jet or pointed tongue of pale flame, which is thrown out in a line with the burning extremities of the piece of yarn. In the same way, if the yarn is enclosed in a tube or other vessel, through which those gases are circulating, and from which one extremity of the gun-cotton protrudes, when the latter is lighted it will burn in the ordinary manner only until it reaches the opening of the tube, when the form of combustion will at once be changed to that just described. If, however, corresponding experiments are made in atmospheres of hydrogen or coal gas, the gun-cotton yarn will burn in the slow manner described, but only for a very brief period; indeed, it ceases to burn at all almost instantaneously, just as it does when ignited in a very highly-rarefied atmosphere. This result is not due to the high diffusive powers of the gas in which the gun-cotton is burned, as it may be obtained equally in open and in perfectly-closed vessels; it can therefore only be ascribed to the high cooling powers, by convection of the gases employed. Pure nitrogen, as stated just now, allows the gun-cotton yarn to burn in the slow manner, but if mixed with one-fourth its volume of hydrogen it arrests the combustion of the material, just like coal gas or pure hydrogen.

A rapid current of air will also effect the transformation of the combustion of gun-cotton from the ordinary to the slow form, if the yarn be enclosed in a moderately wide glass tube, with one end protruding from tube, so that it may be inflamed in the ordinary manner; but unless the current be very rapid, an explosive mixture of air, and the inflammable gases generated from the gun-cotton may be produced in the tube, and become ignited, in which case the gun-cotton will flash into flame instantaneously, and the tube will be shattered by the explosion. If, however, a long piece of thin gun-cotton yarn be passed through a small narrow glass tube, one or two inches long, into which it fits so loosely that it may be drawn through very easily, the change in the form of combustion is effected with certainty, and without the aid of a current of air. When the gun-cotton thus arranged and placed upon a flat surface, is inflamed at one extremity, it burns as usual until it reaches the one opening of the tube; the slow form of combustion then takes place within the tube, and the gun-cotton will continue to burn in the slow manner, emitting only the small tongue of flame, after the combustion has reached the portion of yarn on the other side of the tube, which will be entirely burned in this peculiar manner. In fact to change the ordinary into the slow form of combustion of the gun-cotton yarn *in open air*, it is only necessary to pass a piece of the material through a perforation in a diaphragm of wood, card board, or paper, and to allow it to rest upon a flat surface on both sides of the diaphragm. The gun-cotton will burn as usual upon one side of the screen, until its combustion reaches the perforation, when the large bright flame will vanish and the gun-cotton upon the other side of the screen will burn in the slow manner to the end.

The two last experiments show, that if the combustible mixture of gases evolved by the action of heat upon gun-cotton when it is inflamed in open air, are prevented, even for the briefest space of time, from completely enveloping the burning extremity of the yarn or twist; or, in other words, if they are forced for an instant to escape only in a direct line with the burning surface of gun-cotton from which they are emitted, those particles of the latter which are in immediate proximity to the burning portion cannot be raised to the temperature necessary for their rapid and more combustion, and hence the gases themselves are in turn not supplied with sufficient heat for their ignition. Now, as the gases which escape unburned convey away a very large portion of the heat developed by the metamorphosis of the gun-cotton, it is impossible for the latter to continue to burn otherwise than in the slow and imperfect manner. If, however, a flame or highly-heated body be held in the path of the gases as they escape, they will at once be ignited and the yarn will burst into the ordinary form of combustion. The correctness of this explanation may readily be demonstrated by two or three simple experiments. Thus, if a piece of loose or open gun-cotton yarn is employed in place of the compact material which furnishes the results just described, it is very difficult, or even impossible, to cause the rapid combustion to pass over into the slow form, because the escaping gases cannot be diverted all into one direction, and cannot, therefore, be prevented from transmitting the heat necessary for perfect combustion from particle to particle of the material. Again, if a piece of the compactly-twisted gun-cotton yarn, placed upon a flat surface, is inflamed in the usual manner, and a jet of air is then directed in a line with the gun-cotton so as to meet the flame, the latter will appear to be blown out, though the cotton still burns; in fact, the burning gases are prevented for an instant from completely enveloping the extremity of the gun-cotton, and hence the combustion at once passes from the quick to the slow form. Conversely, if, when the yarn has been made to burn in this slow manner, a very gentle current of air be directed against the burning portion, so as to force back upon the latter the gases which are escaping, thus impeding the rapid abstraction of heat, the gun-cotton will very speedily burst into the ordinary form of combustion, because, under these circumstances, the gases are almost immediately raised to the temperature necessary for their combustion. In the same way, if a piece of the yarn placed upon a board be made to burn in the slow manner, and one end of the board be gradually raised, so that the burning extremity of gun-cotton is the lowest, the latter will burst into flame as soon as the board has been raised to a position nearly vertical, so that the escaping gases flow back upon the burning surface.

The slow or imperfect form of combustion may be at once induced in the compact gun-cotton yarn, in open air, by applying to any part of the gun-cotton a source of heat not sufficiently great to inflame the gases generated. A wire, or metal rod, heated to any temperature between 135° C. to just below visible redness, or the spark of a thin piece of smouldering string, will invariably produce the result described. Of course this effect, like most of the phenomena described, is to a considerable extent dependent upon the mechanical condition of the gun-cotton, upon the relation between the *quantity* as well as the *degree* of heat applied and the amount of surface of the gun-cotton, and upon other conditions. While a small spark, or a thin platinum wire heated to full redness, only induces slow combustion in the compact gun-cotton yarn, a thick rod of iron, heated only to dull redness, will invariably inflame it in the ordinary manner. A piece of open yarn cannot be ignited so as to burn in the slow manner; on the other hand, the more compactly the gun-cotton is twisted, the more superficial is the slow form of combustion induced in it; indeed, the gun-cotton may be rendered so compact that it will simply smoulder in open air, if ignited as described, leaving a considerable carbonaceous residue; and the heat resulting from this most imperfect combustion will sometimes be abstracted by the escaping gases more rapidly than it is developed, so that the gun-cotton will then actually cease to burn, even in open air, after a short time.

The remarkable facility with which the effect of heat upon gun-cotton may be modified, so as even to produce results totally opposite in their characters, as exemplified by some of the experiments which have been described, renders it easily conceivable that this material may be made to produce the most varied mechanical effects, when applied to practical purposes; that it may indeed be so applied as, on the one hand, to develop a force, very gradual in its action, which may be directed and controlled at least as readily as that obtained by the explosion of gunpowder, while, on the other hand, it may be made to exert a violence of action and a destructive effect far surpassing those of which gunpowder is susceptible. The results arrived at in Austria, which show that gun-cotton may be made to produce effects from three to eight times greater than those of gunpowder, cease to be surprising after a study of the chemical and physical characteristics of this interesting explosive agent.

The products obtained by the explosion of gun-cotton, and its decomposition under various conditions, have as yet been very imperfectly studied, but there is little doubt that they vary in their nature almost as greatly as the phenomena which attend the exposure of the material to heat under different circumstances. It is well known that, when gun-cotton is inflamed in the open air, there is produced (in additon to water, carbonic oxide, carbonic acid, and nitrogen) a considerable proportion of binoxide of nitrogen, so that the gaseous mixture assumes a red-brown tinge, and becomes very acid when it mixes with air. The products of the different forms of imperfect combustion which gun-cotten has been described as susceptible of undergoing, are undoubtedly much more complex in their character than those just referred to. They include at times a proportion of some substances not yet examined, which make their appearance as a white vapour or smoke; cyanogen can readily be detected in all the products of imperfect combustion; the proportion of binoxide of nitrogen is generally so large that the gaseous product becomes very highly coloured when mixed with air; peroxide of nitrogen has also been observed in some instances; lastly, there is little doubt that the products occasionally include a proportion of oxidizing gases.

The products which have just been alluded to are the results of the decomposition of gun-cotton either at ordinary or diminished atmospheric pressures; when the explosion of the material is effected in a confined space, in such a manner that the main decomposition takes place under pressure, the metamorphosis which the material undergoes is of a more simple and complete character.

It has been found by Karolyi that, when gun-cotton is exploded by voltaic agency in a shell which is burst by the explosion, and which is enclosed within an exhausted chamber, so that the products of decomposition are collected without danger, the results obtained under these conditions are comparatively simple; the analysis of the contents of the chamber, after the explosion, showed that they consisted of carbonic acid 20·82 per cent., carbonic oxide 28·95, nitrogen 12·67, hydrogen 3·16, marsh gas 7·24, water 25·34, and carbon 1·82. The decomposition of gun-cotton under these conditions (which are similar to those of its explosion when employed as a destructive agent) appears, therefore, not to be attended by the production of any oxide of nitrogen. The lecturer found, in some preliminary experiments made under the same conditions as those of

Karolyi, that only a minute proportiou of binoxide of nitrogen was produced. These results, when compared with those obtained by the ignition of gun-cotton in open air and rarefied atmospheres, show that, just as the decomposition of this material is of a more complicated and intermediate character in proportion as its combustion is rendered imperfect hy dimiuution of pressnre or other circumstances, so, conversely, the change which it undergoes will be the more simple, and its conversion into gaseous prodncts the more complete, the greater the pressnre, beyond normal limits, under which it is exploded; that is to say, the greater the resistance offered to the generated gases upon the first ignition of a charge of the gun-cotton (and consequcntly the higher the temperatnre at which the decomposition of the confined gun-cotton is effected). It is therefore readily intelligible that the notions hitherto generally entertained with regard to the very noxious character of the products of explosion of gnn-cotton and their powerfnlly corrosive action upon metals—based as these notions have been npon the effects observed on exploding gun-cotton in open air—have bcen proved to be erroneous by the results of actual application of gun-cotton to artillery and other purposes. Tho foregoing considerations contribute, moreover, to the rcady explanation of the fact, established by the experiments in Austria, that the destrnctive effect of gun-cotton is greatly increased, within certain limits, hy increasing the resistance which the products of explosion have to overcome before they can escape into the air.

The conditions (of temperature, pressure, &c.) which iufluence the nature of the decomposition of gun-cotton, excrt, unquestionably, a similar infineuce upon the nature of the explosion of guupowder, and upon the mechanical effects which the prodncts are capable of exerting. Observations made by the lectnrer, in experiments upon the ignition of gunpowder in rarefied atmospheres, point to the existence of products of comparativcly complicated character among those found by the gradual decomposition of that material under the conditions described. The earlier investigations (Gay-Lussac, Chevreuil, &c.), of the products of explosion of gunpowder, represent these as being of a very simplc character, and in harmony with the theory that gunpowder is converted essentially by its explosion into carbonic acid (or a mixture of that gas and carbonic oxide), nitrogen and sulphide of potassium. But, more recent experimenters, Buusen and Schischkoff, who have made a very elaborate examination of the products which they obtained by the explosion of gunpowder, represent the change to be one of a very complicated character; fix the percentage of solid substance found at a much higher figure than that hitherto accepted, and show that the sulphide of potassium, which has heeu considered as the principal of these products, was only prodnced in very small proportion, in their experiments. The conditions under which these chemists exploded the gunpowder did not, however, correspond at all in their character to those under which gunpowder is exploded in actual practice, and would, therefore, bc very likely to furnish results greatly at variance with those produced wheu a charge of powder is fired iu a gun, a shell, or a mine. That sulphide of potassium is abundantly produced, upon the discharge of a fire-arm, appears beyond doubt; it may be readily dctected in the solid matter which remains in the barrel near the breech; it may be found deposited in considerable quantity near the muzzle of the arm, and there appears strong reason for believing that the flash of flame, observed at the mouth of a fire-arm upon its discharge, is due in part to the ignition, as it comes into coutact with the air, of sulphide of potassium, which has heeu vaporised by the heat of the explosion, and is thus mixed with the escaping gases.

In comparing the effects of gun-cottou, as an explosive agent, with those of gunpowder, and in basing theories, with regard to the difference in the mechanical effect exerted by the two, upon the analytical results of the product of their explosion which have been obtained up to the present time, it is uecessary to proceed with great cantion; for exceptional results cannot form any sound basis for correct theories or tenable arguments. It can only lead to incorrect conclusions, which may considerahly retard the thorough investigation of a most important subject, if the facts be ignored or lost sight of, that, firstly, the couditious which practically influence the nature of the products of the explosiou of gun-cotton have a similar infinence upon the change which gunpowder may be made to undergo; and that, secondly, the effect of heat upon the water produced by decomposition of gun-cotton, which forms so important an element in the action of this explosive, has most probably its parallel, to no unimportant extent, in the vaporising effect of heat upon the solids (especially upon sulphide of potassium) produced in the explosion of gunpowder. These arc matters which demand their full share of consideration and investigation, before it can be admitted that a sufficient explanation of the remarkable differences between the effects of gunpowder and gun-cotton exists in the assnmption that certain products of decomposition of the former must be regarded entirely as waste matter in the material simply because they are solid at ordinary temperatures. The fact that gun-cotton is entirely converted into gases and vapour at the moment of explosion, constitntes unquestionahly one of the great advantages which that substance possesses over gunpowder: but it is premature, at present, to assume, iu comparing the action of the two substances, that only thirty-two (or even sixty) per cent. of gunpowder exists as gas or vapour, at the moment of its explosion.

It is to be expected that the investigations which are now being actively pursued upon the true chemical effects produced in the explosion hoth of gun-cottou and gunpowder, under conditions similar to those which attcnd their employment in practice, will aid materially in furnishing the correct data so essential for a thorough and impartial comparisou of the natnre and merits of these two explosive agents.

A Great Blast.—An enormous blast has been made by the contractors under the Tyne Improvement Commissioners at the Trow Rocks, South Shields. 2,400lb. of gunpowder were used; and it is estimated that 20,000 tons of rocks were dislodged. Immense fissures were rent in the rock, and huge masses of stone, many tons in weight, were tumbled over in all directions.

INSTITUTION OF CIVIL ENGINEERS.

ON THE MACHINERY EMPLOYED IN SINKING ARTESIAN WELLS ON THE CONTINENT.

By Mr. G. R. Burnell, F.G.S.

It was stated that the extraordinary depth of some borings lately made for the purpose of obtaining an artesian supply of water, had lcd to great changes in the well-borers' art, and to the introduction of various mechanical processes, and of modifications of machinery, into the merits of which it was desirable to inquire.

The first well of this kind was that at the Abattoir of Greuelle. This was sunk, after eight years' incessant labour, a total depth of 1,797½ft. (English), and gave rise to many inventions for the purpose of facilitating the progress of the works, for removing the hroken tools, for the introduction of the pipes, and for carrying on observations at various depths from the surface. Subsequently, many similar wells were sunk on the Continent, particularly in the Rhine provinces, but they were all of small diameter. The German engiueers introduced important modifications in the tools. Æunyenhausen made the striking part, used for comminuting the rock, to slide, so as to fall always through a certain distance, and thus avoid a jar. M. Kind had already applied his system to large excavations for winning coal mines, when he was entrusted hy the Municipal Council of Paris with the execution of the well at Passy. This was to have a diameter of one metre (3ft. 3$\frac{7}{16}$in.), that of Grenelle being only 20 centimetres (about 8in.) The difficulties encountered in carrying the excavation through the clays of the upper series were so serious, that six years and nine months were occupied in reaching the water-bearing stratum, which was ultimately attained at a depth of 1,913ft. 10in. from the surface, when the yield was 3,349,200 gallons per day, of twenty-four hours, subsequently increased to 5,582,000 gallons, and then continued at 3,795,000 gallons per day. The total cost of the well was £40,000. It was lined with solid masonry for a depth of 150ft.; then wood and iron tubing was introduced to 1,804ft. from the surface, and below that there was a length of copper pipe pierced with holes.

The result of this well had been so satisfactory as regarded the quantity of water, that the authorities had decided to execute at once two additional artesian wells, and there were rumours that two others were contemplated.

There were threc different systems of well-boring, mostly dependent on the nature of the tools; the Chinese, or M. Fouvellc's; the French, or rather the usual well-borers' plan; and M. Kind's. In the first, the motion given to the tool in rotation was simply derived from the resistance that a rope would exercise to an effort of torsion, and therefore the limits of application of the system were only such as would allow the tool to be safely acted upon. Besides, a considerable quantity of water was required to clear out the boring, so that this plan had been almost universally abandoned. In the ordinary system of well-boring, the weight of the tools and of the solid-iron rods hecame so great, when the excavation was deep, that there was considerable difficulty in transmitting the blow of the tool, in consequence of the vibration produced in the long rod, or in consequence of the torsion. Hollow rods, filled with cork, aud M. Æuyenhausen's joint, which permitted the tool to fall freely, and through the same height, every time it was released, were now employed. M. Kind adopted both these modifications, and in the well of Passy, he substituted oak rods for iron ones, as heing lighter, and more easily couuterbalanced in water. The products of the excavation were still most frequently removed by augurs and chisels; and all the processes hitherto practised were cousidered to be more or less defective, as in every case the comminuting tool had to be withdrawn. In the well at Passy, M. Kind employed a trepan to comminute the rock; it weighed 1 tou 16 cwt., and fell through 2ft. This tool was composed of two principal pieces—the frame and the arms—both of wrought iron, but the teeth of the cutting part were of cast steel. The frame had at the bottom a series of holes, slightly conical, into which the tceth were inserted, and were tightly wedged up. These teeth were placed with their cutting edge on the longitudinal axis of the frame that received them; and at the extremity of the latter, there were formed two heads, forged out of the same piece with the body of the tool, which also carried two teeth, placed in the same direction as the others, but which were made of double the width of the latter, in order to render this part of the tool more powerful. It was by increasing the dimensions of these end teeth, that the diameter of the boring could be augmented so as to compensate for the diminution of the clear space by the tubing that it might be necessary to introduce iu traversing strata disposed to fall in, or to allow the waters from below to escape at an intermediate level. Ahove the lower part of the frame of the trepan was a second piece, composed of two parts bolted together, and made to support the lower portion of the frame. This part of the machinery also carried two teeth at its extremities, which served to guide the tool in its descent, and to work off the asperities that might bc left by the lower portion of the trepan. Above this, again, were the guides of the machinery properly speaking, cousisting of two pieces of wrought irou arranged in the form of a cross, with the ends turned up, so as to preserve the machinery perfectly vertical in its movements, by pressing against the sides of the horing already executed. These pieces were independent of the hlades of the trepan, and might be moved closer to it, or further away from it, as might be desired. The stem and the arms were, lastly, terminated by a single piece of wrought iron, which was joined to the frame hy a kind of saddle joint, and was kept in its place by means of keys and wedges. The whole of the trepau was finally jointed to the great rods that communicated the motion from the surface, by meaus of a screwed coupling, formed helow the part of the tool that hore the joint, which permitted the free fall of the cutting part, aud united the top of the arms and frame aud the rod.

LONDON ASSOCIATION OF FOREMEN ENGINEERS.

At the ordinary monthly meeting of this society, on Saturday, the 4th ult., Mr. David Walker, of Messrs. Maudslay, Sons, and Field's establishment, read a paper on the Screw Propeller.

The reader commenced by stating that it was not his intention to trace the history of screw propulsion, as that was probably well known already to those he addressed. The idea of using the screw as a propeller, no doubt arose from the employment, as a mechanical toy, of the old water screw which had been known for centuries. Messrs. Bramah and Shorter, about the beginning of the present century, may be said to have been practically the pioneers of screw propulsion. The screws devised by those gentlemen differed considerably in form from each other, and resembled those subsequently introduced by the rival champions—if the term were admissable in a scientific sense—Smith and Ericsson, who ventilated, and worked out the subject thoroughly. Bramah's propeller might be regarded as the parent of Ericsson's, and Shorter's that of Smith's. To the last-named gentleman belongs the merit of bringing the screw into actual use and making it a formidable competitor with the paddle-wheel. This was said, however, not in disparagement of the host of inventors and engineers who had devoted attention to modifications in the form, and in the manner of it application, and which included such men as the Rennies, Mr. Perkins, Lord Dundonald, and the Maudslays. Entering the arena at about the same period, Ericsson and Smith struggled manfully against difficulties and prejudices, and passed through careers which were nearly parallel in their incidents and results. Smith's first patent was taken out in May, 1836, Ericsson's in July of the same year. Smith's model of a screw propeller was first publicly exhibited towards the end of the year in which he had secured his patent; Ericsson early in 1837. The first boat constructed by Smith, of six tons burden and six horse power, was tried soon after on the canal at Paddington and on the Thames, and at the same time Ericsson was achieving perhaps a greater amount of success on neighbouring canals and the same river.

In the summer of 1837, Ericsson invited the Lords of the Admiralty to test the value of his invention, and in the spring of 1838 their lordships requested Smith to put his vessel under their inspection. It is said that my lords entertained doubts as to the practicability of Ericsson's plans, but the nature of those doubts, if they existed, was shrouded in that convenient covering, "official reserve." Smith's experiments were successful, and under Government patronage the well-known vessel the *Archimedes* came into existence. Private enterprise furnished Ericsson with the *Robert Stockton*, which ship, after a few trial trips in this country, transferred the inventor to the United States of America, there to pursue a course of honourable rivalry. Thus was lost to this country a brilliant engineering and mechanical genius, a bold spirit daring enough to thread his way through untrodden paths and to sketch out new roads for men of less original minds to walk in, and prosper. Ericsson possessed the rare faculty of attaching to himself those who worked with and under him, and of inspiring them at once with esteem, confidence, and enthusiasm. Smith was not less entitled to commendation, his perseverance and ingenuity had indissolubly linked his name with screw propulsion, and the honourable post which he now so ably occupied had undoubtedly been fairly earned.

Mr. Walker said there were many questions in connection with the subject he had that evening undertaken to speak upon which was difficult of solution, and upon which much difference of opinion existed among marine engineers. One of these referred to the loss of propelling power due to the "slip" of the screw. He did not say it presumptuously, but it had often struck him that there were frequently many slips of the tongue among engineers and others as touching this matter. Slip was usually calculated as the difference between the actual speed of a vessel and the speed of her screw, supposing the latter to be working through a nut in place of a yielding substance like water. This difference was often spoken of as demonstrating a decided loss of power. Hence the problem had been propounded of devising a screw which should work without slip. That slip is an essential element in marine propulsion seemed clear from the fact that to obtain pressure or thrust on the paddle float or screw there must be motion through the water. The water must be disturbed—a body of it pushed, so to speak, out of its place. The resistance it offers to this disturbance was the thrust obtained for the propulsion of the vessel. The amount of this thrust appeared to depend upon two conditions, namely, the speed at which the body or float was moved in the water and the depth at which this motion takes place. The resistance or pressure thus obtained stood in a fixed ratio to the motion of the float. This ratio had been ascertained and reduced to simple formulæ by men of science, and in like manner he (the reader of the paper) believed there was a fixed ratio between the power expended on the stern thrust and that exerted in the propulsion of the ship. This proposition he had as yet seen no solution of, but he had attempted, rudely it might be, to work it out. The motion of the vessel through the water was the counterpart of that process by which thrust was obtained on a paddle float or other propeller. The water at the bow of the vessel was displaced and resisted the forward motion of its inertia, and thus resistance was overcome by obtaining a pressure towards the stern equal to the resistance at the bow. The water was thus pushed astern to the same extent, and with equal force to that by which headway was made. The propeller, therefore, whether paddle or screw, kept up the thrust astern until the pressure equalled the resistance of the water pushed from the bow, and the forces balanced each other. At this point the vessel would have gained her maximum rate of speed. From this data, which was open to correction, and which it was not intended arbitrarily to put forth as exact and infallible, he concluded that one half the power of a vessel was always expended in producing thrust motion, and the other half in displacing the water at her bows and in overcoming the friction of her sides and the stern drag. In other words, were engines of half the ordinary power employed to pull on a tow rope, the same speed would be obtained.

Some had asserted, and among them their president, Mr. Newton, in his explanation last year of Vailes' endless chain propeller, that the same engines would, under these conditions, double their speed, but this was not so clear to himself. If there were any truth in the theory now advanced, it would go to show that the slip really absorbs half the power of the engines. The ship and propeller were to be regarded as parts of the same machine, and adapted to each other. The lines of the former should be fine under the quarter, in order to get rid of the eddy which followed a heavily-shaped vessel, and that really retarded her progress. Hence, too, arose that anomalous phenomenon known as negative slip, in which case the screw, by working against the current following the ship, gave out a speed of vessel greater than was due to the revolutions or the pitch of the screw, and caused a considerable waste of power. The late Mr. Joseph Maudslay had directed much profitable attention to this latter subject, and divised an arrangement of the lines of vessels which was peculiarly adapted for screw propulsion, as well as being of great advantage for sailing vessels and paddle steamers. By his plan the after current was got rid of, and the screw acted upon comparatively unbroken water.

The screw should be in all cases accurately proportioned to the size of the ship, its diameter being as large as the draught of water would admit, and the number of blades suited to the diameter. In the earlier experiments with the *Archimedes* and the *Rattler*, screws were tried with two, four, and six blades, but he did not think that the length of the screws had been regulated in proper proportions, or those experiments would have demonstrated what had subsequently been proved, namely, that an increased number of narrow blades was superior to a smaller number of broad ones. The thrust to be obtained by a wide blade was not to be measured by its surface, for the water when it had been acted upon had had motion imparted to it, and was no longer effective for thrust. It might, indeed, become a drag, as was exemplified in Smith's first screw of two and a half turns. When one half of the blade in this case was broken by accident, the vessel doubled her speed immediately.

The vibration imparted to the ship by the action of the screw was one great objection to its employment. Much had been done to obviate this evil by curving the leading edge of the blades, and by other means. Griffiths undoubtedly stood prominent with improvements in this direction. He had curved both leading and following edges of screw blades, and made them widest in the middle, after the manner to some extent of the paddle of a South Seas Indian. This mode of dealing with screw blades had, however, been previously worked out by the late Mr. Maudslay, in a series of experiments on board his own yachts of 105 tons, the *Water Lily*, the *Firefly*, and the *Sunbeam*, which were expressly built for the purpose. In these he also demonstrated the advantages of his own feathering screw, which for efficiency and symmetry of form he (Mr. Walker) believed to be as yet unrivalled. This allowed of the screw-hole being closed when the vessel was under canvas only, and thus materially improved her sailing and steering qualities.

The two-bladed screw had been until lately almost exclusively employed by the Admiralty, and it certainly possessed the advantage of portability. It could be lifted out of the water when the ship was under sail, and lowered into it again when required by an operation managed on deck. The blades were necessarily made of considerable width, in order to give surface. Latterly, however, the lifting-out operation had been sacrificed in order to obtain the greater benefit of more and narrower blades. Instead, therefore, of giving one sixth or seventh of the pitch, or convolution, and two blades, the growing practice is to employ screws of four blades with one-twelfth or one-fourteenth of the pitch. The consequences of this was that less slip and greater efficiency was obtained. The engines were disconnected when the vessel was under canvas, and the screw thus allowed to rise loosely in its bearings.

Mr. Walker, said he gave the preference to a form of screw not much in use in this country, and which consisted of narrow blades of scymitar-like shape. By this arrangement, vibration—resulting mainly from the sudden shock of the upper and lower blade striking the water in close proximity to the stern post—would be largely obviated. It also caused the more effective part of the blade to be thrown back, as it were, out of the eddy of the ship, and this had long been his favourite idea in regard to the screw propeller; and lately he had had an opportunity of seeing it, in one instance, most successfully realised. An old straight-bladed screw had been displaced in order to make room for one with curved blades, and the speed of the vessel in which the experiment was tried had been materially increased by the change.

Double or twin screws were also engaging the attention of scientific and practical men; they were right and left-handed, and were placed one under each quarter. He had no faith in the supposition that they would supersede the single screw except under very peculiar circumstances, and they did not effect the anticipated benefit of turning a ship quickly, and in her own length. The leverage between the two screws was not sufficiently great to act upon the length of the vessel, and this counteracted each other's influence, and brought the ship to a dead stand. More complicated machinery, too, was involved in their application, and, after all, it was only in ships of very light draught and heavy burden, moving in shallow waters that they could be advantageously used. Perhaps, these conditions were presented in some of our steam rams and floating batteries, where the width of beam and weight were large and heavy.

Mr. Walker regretted that he could not then enter into the question of the progress of the screw on canals, where it may be said to have been born, but where it seemed slowest in developing itself. During the last few years a member of their own association had devoted his energies and talents to the promotion of screw propulsion on canals, and with marked success. Much yet remained to be done in this direction, both at home and abroad, and he trusted that much yet would be done.

The paper was well received, and was illustrated by some very nicely executed mahogany models of screws, made by pupils of Messrs. Maudslay.

LIVERPOOL POLYTECHNIC SOCIETY.

ON TURBINE WATER-WHEELS.

By C. Schiele.

In the onward course of improvements in machinery there are periods when the attention of the public is directed more particularly to a subject which attracts by its bearing and influence on the wants and comforts of human society, as contrasted with the influence exercised thereon by time-honoured usages or practice, and among these subjects may be classed Turbine Water-wheels. To the general public the problem of applying water, in order to obtain rotary motion from a wheel, may seem a simple one indeed, since that has been done in various ways for centuries past—first by the plain float-wheel, where the water acted by impact simply; then by the float-wheel moving in a wheel race, where the water acted partly by weight and partly by impact; and later on by the bucket-wheel, where the water acted by its weight only. Water-wheels, however, are too uncertain to be depended upon for regular use, and too sluggish for this age of high speeds. Frequently they absorb a deal of valuable room, and sometimes they spread unhealthy dampness inside the building where they are at work; hence, the consequence has been that many water-wheels have been stopped altogether, and the water allowed to run past wasting its living power, an eyesore to the economist, and a nuisance to the manufacturer who has to pay heavy coal bills instead.

To use more precise mechanical language, water-wheels, as generally known, are slow movers, because the water having to act by weight should fall slowly, and as a necessary sequence, heavy and compendious gearing has had to be applied in the generality of cases, in order to obtain quicker speeds. The user, however, and in many cases the millwright also, would rather have a quick speed reduced to a slower one, and this want or desire has led human ingenuity to devise that class of hydraulic motors known generally as reaction-wheels, of which the turbine, though not strictly speaking a reaction-wheel, may be called the ultimate or final result,—and in which the water acting by pressure, or by momentum, but not by impact, produces great speeds even in moderate falls.

The construction of a practically perfect turbine-wheel is a subject which severely taxes the intelligence of him who undertakes to solve that problem, the points to be watched, or the conditions to be realised being so numerous and sometimes at variance with each other. We will now pass in review the various conditions, the realisation of which should be aimed at in the construction of turbines, and these are as follows:—

1st. Economical adjustability to the variation of water quantities, or to the variation of power.

One great desideratum is to realise the same per centage of useful effect, whether the wheels be worked to its full power or not, that is, whether the wheel consumes its maximum quantity of water, or any smaller quantity; a water engine, in fact, ought to be like a steam engine. In the case of the latter when there is little work, less steam ought to be consumed, and in a similar manner should the former admit of the adjustment of the flow of water in proportion to the work to be performed; and, moreover, it should do this by means of self-acting apparatus, as is almost invariably done in the steam engine. At the same time the smaller quantity of water should be used to its greatest possible advantage, or in other words should yield the same per centage of useful effect. This condition is easily realised in a common bucket wheel so long as the water course is not flooded, but as soon as the water in the tail race rises so as to immerse the buckets, so soon is there an end to the economical working of the wheel, and it is an event of frequent occurrence that water-wheels are stopped not from want of, but from excess of water.

2nd. To maintain the highest top level and uniform speed.

In properly constructed machines the power is just proportional to the head; and it is important, therefore, to establish and maintain the highest possible level; the speed, moreover, varies in a certain ratio with the head, and thus there are two very cogent reasons why the head should not be allowed to vary. Uniformity of speed, however, is aimed at also, by varying the quantities of water with the quantity of work to be performed, but this condition is of such vital importance in certain operations, as for instance in spinning, that the machinery must be stopped when the driving apparatus moves too quick, and its realisation, therefore, should be aimed at by every possible means.

3rd. To maintain clear open water ways, without liability to choke up by sticks, leaves, or other floating materials which might pass the usual strainer.

This is a point which requires great attention, and which has always been a great drawback to turbines, for when leaves, branches of trees, or other obstructions get into them, they become as bad as water-wheels in backwater. I have seen one of my own turbines of the old patent, which had become so fast that a four ton crane had to be used to tear up the rubbish.

4th. To bring the water into the turbine without cutting it up into too many small veins.

This is important also because the more the water is cut up, the greater is the loss of power by friction.

5th. Simplicity and durability in construction.

6th. To introduce the water in a direction tangential to the rotary motion of the wheel, and to obtain a radial outflow; this efflux, moreover, should be perfectly smooth, and should produce no foaming and no agitation.

Whenever this takes place, the whole energy originally contained in the water has been given up to the wheel, and the only loss of useful effect is that due to the friction of various parts of the machinery; but when there is any considerable disturbance, any bubbling up of the effluent particles of water, this is a sure sign that the whole of the energy has not been given up. The curve of the vanes of the turbine should be such as to transform the originally tangential motion into a radial motion by easy degrees without shocks.

7th. The turbine should admit of a certain variation of speed without lessening the per centage of useful effect.

8th. Where backwater diminishes the fall in times of flood, the construction of the turbine should admit of a greater body of water passing through it in the unit of time, in order to give out the same power as before.

Turbines, as a general rule, are not affected by backwater in the same way as ordinary water-wheels, and this indeed constitutes one of their greatest advantages; but when the water in the tail-race, if that term can be used here, and whenever the backwater rises so much as to reduce considerably the effective head, the power given out must of necessity diminish in the same proportion, unless a greater mass of water is sent through the turbine.

9th. Where reservoirs are provided, the turbines ought to open for such consumption of water as will drain the reservoirs towards stopping time, and be allowed to fill again with the water otherwise washing over the weirs.

10th. The greater portion of the weight of the turbine should be floated or balanced, so as to diminish the friction on the foot-step.

11th. The rotary motion of the turbine should be perfectly smooth and steady, without shocks or tremour.

12th. The flow of water through all the orifices of the turbine should be continuous and without periods of intermission.

13th. The water should meet with the least possible frictional resistance during its flow through the turbine.

14th. There ought to be the least possible waste of water by leakage.

15th. The construction of the turbine should be such as to realise the benefit of any fall below the turbine, and this even where it does not work to its full power. To this effect a pipe should be attached to the turbine, through which the water is taken down to the tail-race, and the water is then said to act by suction.

16th. The turbine should run horizontally, or in other words it should revolve upon a vertical axis.

17th. The construction of turbines should be such as to make them applicable to falls even less than twelve inches.

In various countries, as for instance, in Mexico, Jamaica, the United States, and others, there are large but sluggish rivers from which power might and should be obtained, but where common water-wheels are absolutely inapplicable; a well-designed turbine, however, may be applied with very good results to falls of a few inches only, from the simple reason that it is not affected by back-water: several of my turbines have been applied to falls of six inches only.

The oldest known form of turbines consists of a wooden vertical shaft resting in a foot-step, and in an upper bearing; upon this shaft four or more projecting boards are fixed, a stream of water is directed against these, issuing from a spout, and motion is thus communicated to the shaft.

In this machine the water acts by impact as in the old float-wheel with which it is identical, there being only this difference, that it moves in a horizontal instead of a vertical plane. Theoretically, water which acts by impact can only give off 50 per cent. of its energy; but in practice it is found that such wheels seldom realise more than 25 per cent. of the total energy of the water expended. Some of these turbines may yet be found in a few remote districts of Upper Egypt, and in mountainous countries abounding with high waterfalls, as for instance Switzerland.

Another form of turbine is the one well known by the name of Barker's mill, which is the prototype of what are termed reaction-wheels. In books this wheel is generally represented with the water issuing in a direction almost tangential to the curve of the arms at their orifice; that, however, is an error, for if it were so, it would imply that the water had not given off any portion of its energy; it very nearly is the case when the wheel is allowed to run without doing any work, but merely overcoming its own friction, as soon, however, as it is loaded the water issues more in a radial direction.

Next in order comes Fourneyron's turbine, in which direct action and reaction are combined. In this machine the water flows down a central

pipe, and is guided by means of numerous blades into an external revolving drum provided also with a number of curved blades against which the water expends its energy; the drum revolves in a horizontal plane, and the object of the guide blades is to introduce the water in a tangential direction upon the blades of the revolving drum in order to avoid shocks, and when the wheel is well constructed the water issues from the drum in a radial direction.

Sometimes the capacity of turbines for giving off power is regulated by a ring sliding up and down as occasion requires, between the guide blades and the revolving drum, thus increasing or reducing the water passages; inasmuch, however, as the capacity of the revolving drum for giving off water remains unchanged, a great disturbance of the filaments of water takes place as they issue through a small orifice into a larger space, and a great loss of *vis viva* follows of necessity, having for its result the inconvenience of a reduced velocity of the wheel; sometimes also this object is accomplished by means of a throttle valve in the descending pipe, but the effects of this method are similar exactly to those previously enumerated; it may also be accomplished by means of separate slides closing one or more of the guiding channels entirely; this method, however, is open to still greater objection than the former ones, for where an interruption of the flow of water takes place into any portion of the revolving drum, that portion fills itself with dead water from the tail-race which has to be driven round by the turbine, thus leading to all the disadvantages of a common wheel working in back water, while as soon as it reaches again an open guide channel, the live water has to drive the dead water before itself by impact, thus causing an additional loss of energy, and besides this, occasioning great shocks and tremours in the whole structure of the machine which are often a great disadvantage to the performance of the work in the mill, and should be avoided at all times.

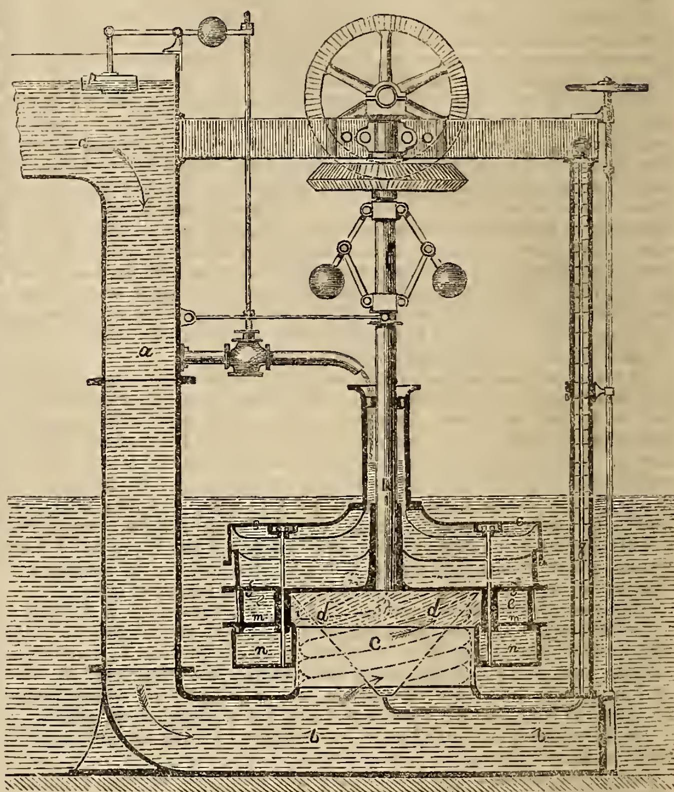
Next in succession we meet with Jonval's or Koechlin's turbine which is an improvement upon the former in so far that the guide blades catch the water in its straight downward course, and by a spiral motion transform it into the requisite tangential motion at the inner periphery of the working drum, thus avoiding the disadvantage and loss of useful effect caused by the abrupt change of a vertical downward motion into a horizontal motion. The methods of adjustment of the flow of water to the variation of power are identical in principle with those enumerated in the previous case, and are liable, therefore, to the same objections.

Next comes what I believe to be the American turbine, but which is better known here as Professor Thompson's whirlpool wheel, or vortex wheel. Here the water is led spirally by means of an external pipe into a central revolving drum in which the water preserves its spiral motion, and finally issues near the axis of the drum in a direction which should, here also, approach as near as possible to the radial line; in this wheel, therefore, the area for the efflux of the water is considerably smaller than the area for the influx, a circumstance which is in itself a great drawback, for since the speed of the outflowing water should be as little as possible it is quite evident that here it must be greater than in turbines of the construction previously described. The speed of the water flowing into the wheel, moreover, is retarded by the centrifugal force which the particles of water already contained in the wheel, have acquired by virtue of the rotary motion of the wheel, a reduction of speed which is equivalent to a loss of head. Supposing such a wheel to be coupled with a steam engine, it would be quite possible to increase the speed of the latter above the proper working speed of the former, until it had reached a point when the vortex must act as a centrifugal pump, raising the water out of the tail-race, a consideration which verifies the remark previously made respecting the loss of head, or power, in overcoming the centrifugal force.

Next comes Schiele's old turbine, invented by myself about ten years ago. Here the water enters a spirally formed chamber outside a cylinder, and is conducted into the interior of the same by means of numerous guide blades. The working wheel is a smaller cylinder turned so as nearly to fit the outer one, and provided with a double series of blades springing from a central feather on each side of it; the blades are so constructed as to allow the water to flow out in a direction parallel to the axis of the wheel, which axis is horizontal, the wheel revolving in a vertical plane. This turbine it will be perceived partakes, in a mitigated degree, of the defects inherent to the vortex wheel—the water flowing from a larger cylinder into a smaller one.

Finally, I wish to draw your attention to the turbine patented by me in 1863, and illustrated in the accompanying wood cut, in which I believe are combined, as far as practicably possible, all the conditions required to make a practically perfect machine.

In this turbine the water enters when admitted through the tube *a* into the tubular foundation plate *b*, from whence it rises into the circular tube *c*, placed outside a cast iron cone, which is provided with spirally formed guide blades *d*, rising higher than the ring or tube *c*. This cone diminishes the area of the water passages uniformly, so that if a ring should close the lower projecting half of the guides their area would be diminished one half, if one quarter, one quarter and so on. The water passing through the guide spaces is not delivered into the turbine-wheel throughout their whole width, but on the external circumference of the spiral openings, or in an almost perfectly tangential direction, whereby all shocks are prevented to such extent that strong cast iron blades may be used for the turbine-wheel *f*, facing the guides *d* with a part cylindrical form, and with a sharp cutting edge



forward, and tapering then out to a fine edge. This construction allows of a considerable reduction in the number of wings, whereby the water passages are made so large in most cases that strainers with their rods from three to four apart, are quite sufficient to prevent interference from floating materials with the working of the turbines, or in case sticks should really get in between the wheel and the guides, they are cut off by the sharp edges of the wings *e*, and of the spiral guides *d*. Should it, however, occur that the wheel became choked up, it may be easily cleared by raising it from its working position, and lowering it again after having washed out the guide spaces; in order also to clear obstructions which may collect in the hollow foundation plate *b*, a flush gate provided for that purpose is occasionally opened. The wings, *e*, are cast upon a disc, *f*, which is fixed to the spindle by means of a coupling; and a wedge, *k*, holds the disc, or turbine wheel down on to the plate. The pivot on which the spindle turns is shown by dotted lines, it is made to the form of the anti-friction curve and supplied with oil by the tube *l*. The water passages between the wings, *e*, are adjustable in their heights by means of a disc, *m*, which allows the wings, *e*, freely to enter the same through openings provided for that purpose, a particular kind of joint being used which answers all requirements. A casing, *n*, is formed on the underside of the disc, *m*, receiving those portions of the turbine wings which are not then actually at work; the inner ring of the casing which slides up and down between the wings, *e*, and the guides, *d*, adjusts the area of the guide passages in the same proportion as the disc, *m*, adjusts the wheel passages, thus realising the great desideratum of altering simultaneously the areas of the guiding passages and the passages in the working drum, in order to obtain a practically perfect turbine, adjustable to the variation of power required; this, indeed, is the great feature of this new invention. The disc, *m*, and the casing, *n*, receive their vertical sliding motion from bolts passing through the wings, *e*, and fixed to the cover *o*, over the turbine wheel, *f*. This cover, *o*, fits into an annular projection of the wheel, *f*, but freely allows of a constant leakage of the water supplied by a valve in connection with the ball-governor. A pipe concentric with the vertical shaft is fixed to the cover, and opens into the same; it is provided with a guide on its upper end, and in the up and down motion it slides upon the vertical shaft. In order to raise, *o*, and with it, *m*, and *n*,

it is only necessary to admit water into the central pipe, which, as its level rises therein, produces a great pressure upwards upon the underside of the cover, *o*, owing to the large area of the latter. No sudden overstroke of this adjustment can happen as the column of water would at once diminish and check the moving force. The ball-governor regulates the supply of water to the cover, *o*, but the float, *p*, also has a regulating action on the water supply to the central pipe in case the governor should allow too much water to pass to the turbine. This is more particularly useful where turbines run in connection with steam engines which supply the remainder of the power required when the water supply is insufficient. The pressure produced under the central portion of the disc, *f*, balances the greater portion of the weight resting on the foot-step of the spindle. The float, when set out of action can be placed in such a position as will allow the turbine to consume larger quantities of water with a view to emptying reservoirs before stopping time. The water as it issues from other turbines generally indicates a separation of currents, not a compact water mass, and with them the direction of efflux is seldom radial to the wheel, but this turbine in which the two discs, *f* and *m*, project considerably beyond the tips of the wings, *e*, and in consequence of which the inclination of these wings to the radial line may be increased considerably as compared with others; the efflux of the water is more steady and uniform, and its direction more radial.

These turbines, therefore, may be said to be constructed so as to fulfil all the conditions previously enumerated, as constituting a practically perfect machine, and practice already has verified this assertion. Where abundance of water makes economy unnecessary, or where the work to be done remains a constant quantity, the self-adjusting apparatus may be omitted.

I trust I shall have the satisfaction, ere long, to make you eye-witnesses to the correctness of my statements, perhaps when one of your annual excursions may lead you near a place where a larger one of these turbines is at work.

THE EAST INDIA IRRIGATION AND CANAL COMPANY.—It appears from the report of the directors, presented to the sixth ordinary general meeting that the progress made during the last six months in surveying and constructive operations in India has been very satisfactory. The preliminary proceedings involved in the planning of a general system of works to control and utilise the rivers of the extensive territory subject to the Company's operations, so as to provide thoroughly effective irrigation and lines of water communication best suited to meet the wants of the people, and therefore best calculated to yield the largest amount of returns, have—the directors report—been conducted with ability and vigour; and that plans and estimates of portions of the works proposed to form the desired system have been prepared, and are now before them for examination and approval. In order to arrive at the realisation of returns, and to demonstrate the productive character of their project at the earliest possible moment, the directors resolved to take up at once and to urge on speedily certain works regarding which they had received certain data, viz.—the weirs, sluices, and other masonry works at the head of the deltas; the first and last sections of the High Level Canal, viz.—from Cuttack to the Brahmany River, and from Midnapoore to the Damoodah River opposite the western termination of the Oolaberiah Canal; the improvement and completion of the last-named canal; and the Tidal Canal from the Roopnarain at Tumlook to Balasore, forming a continuous line of navigation between the latter town and Calcutta. Of these initiatory works it has since been found advisable to give the preference to, and concentrate the principal available resources and efforts upon—1st, the completion of the Oolaberiah Canal between the Hooghly and the Damoodah; 2nd, the excavation of the canal from the Damoodah end of the Oolaberiah Canal to Midnapore; and, 3rd, the excavation of the Tidal Canal from Tumlook to Balasore; and accordingly special attention has been directed to those works. The Oolaberiah Canal was transferred by the Government to the Company in an incomplete state, a diversion at either end and the addition of tidal locks being required to render it navigable at all times, as well as suited to form the Calcutta terminal section of the Company's Canal to Midnapore, and of their Tidal Canal to Balasore. The Oolaberiah Canal, in its unfinished state, was opened temporarily on the 1st of May, 1863, and the receipts from tolls, ferries, &c., levied, with the aid of Government, upon it during that month exhibited a highly satisfactory per-centage upon the purchase-money paid by the Company, and those tolls continued to increase until early in October last, when it became necessary to close the channel in order to effect its completion and improvement. The executive engineer in charge of this work and of the connecting line to Midnapore, has reported that he will be able to execute so much of the needful works as will enable the canal to be re-opened permanently for traffic within a few months. The excavation of the succeeding portions of the High Level Canal—that is, from the Roopnarain to Midnapore—is intended to be carried on with as much rapidity as the supply of labour and material will allow; and they will, with a continuation of present resources, according to an assurance given by the engineer last referred to, and confirmed by the acting chief engineer, be so far proceeded with by about January next as to be capable of being then opened for navigation to Paunchkorah, about midway between the Roopharain and Midnapore. The whole line to Midnapore will, as the directors are informed by the same officers, be ready for navigation by or about July, 1866. In addition to the favourable returns from navigation expected to be produced upon the line of canal to Midnapore thus described, there is between Paunchkorah and Midnapore, a large tract of land which will be commanded by the canal, and of which about 20,000 acres, the directors are informed by their manager and engineers, may be reasonably calculated upon as available for irrigation by the dry season of 1865-6, and this land is described as being of the very richest kind. It will be gathered from the foregoing remarks that it is probable within a few months a canal of about twelve miles in length connecting the navigation of the Hooghly and the port of Calcutta with the Roopnarain River, accommodating the upper traffic of the last-named river, and also connecting Tumlook, the present place of shipment for Calcutta of the Midnapore traffic, will be permanently opened for public use—that an additional twelve miles of canal and four miles of river way, forming a nearly straight line to Paunchkorah on the Cossye, so as to convey the traffic of that river to Calcutta, may be expected to be opened by January, or say July, 1865, and that the remaining twenty-five miles of canal between the Cossye and Midnapore may be rendered navigable and capable of affording irrigation by the month of July, 1866. Should all this be achieved, it will still remain to perfect the whole line, and to furnish it with the necessary tidal locks and Masonry works, not interfering with navigation. With reference to the Tidal Canal from the Roopnarain to Balasore, the intention is to pursue the same course as that described in connection with the canal to Midnapore, viz.—to excavate the channel so far as to enable it to be opened for navigation, postponing until afterwards the perfection of the canal and the construction of its masonry works, as by so doing they are encouraged by the reports of their engineers and manager to hope that the line from the Roopnarain to the Huldee River, and from thence to the Russoolpoor River, a distance of twenty-six miles, may be brought into operation, and be enabled to receive the traffic of those rivers in the course of a few months. Should this expectation be realised, a water communication of eighty-nine miles will be created between Calcutta and Balagai, a place of some importance on the Russoolpoor River, at a point about ten miles above the junction of the canal with that river, and of which communication the Oolaberiah Canal and its continuation to the Roopnarain before refore referred to will form portions, and the importance of these be materially increased. The supply of labour in the locality has been found to be moderate, but not to the full extent desired; at the end of February last 5,000 Coolies were employed upon the excavation. Beyond the progress made upon the two canals just described, a considerable amount of work has been performed upon those other portions of the scheme which were selected for first operations. In connection with the Mahanuddy and the Beropa Anicuts, and the Head works at Cuttack, several stone quarries have been opened in the neighbourhood, and a large quantity of stone has been quarried ready for use. Tramways have been laid from the quarries to each anicut, the whole of which tramways were expected to be in active operation in the course of March last. At the Mahanuddy Anicut the sinking of wells in the bed of the river has been steadily carried on, whilst those for the centre sluices have been sunk to the full depth. The excavation for the south abutment of the same anicut was nearly finished at the commencement of March last, and the masonry of that abutment was then to be commenced in the course of a few days. The abutment and wing walls of the head sluices at the canal at Johra, just above the Mahanuddy Anicut, were said to be well forward at the same date, and their stone floorings were being laid. Upwards of 500 wells for the foundation of the Kajoree Anicut and head sluices have been sunk, but further operations on this work have been temporarily suspended in order that the two important canals to Midnapore and Balasore may be the more rapidly executed. The Naraj Weir or Anicut, which had been handed over to the Company by the Government, is being thoroughly reinstated prior to its extension across the river. In the immediate locality of each of the anicuts and head works very large quantities of material—brick, stone, timber, charcoal, &c.—have been collected or manufactured, and much has been effected to expedite future operations. Portions of the machinery sent out from England had likewise been erected and brought into use with advantage and great satisfaction, and the manufacture of tools and implements has been favourably commenced. Surveying operations have likewise been energetically pushed forward in the upper portions of the Mahanuddy River for the discovery of the most favourable sites for reservoirs, and for determining the exact line of the intended canal to substitute the river itself where the latter is impassable.

ON THE PARABOLIC CONSTRUCTION OF SHIPS.

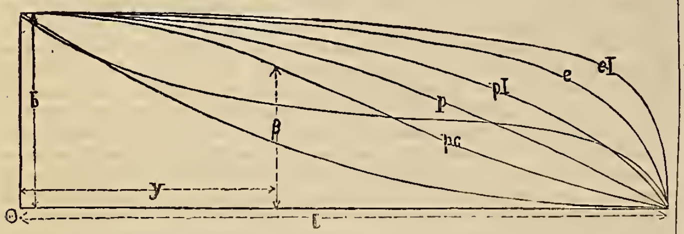
From a Lecture delivered at the Polytechnic College, Philadelphia, U.S., and published in the "Journal of the Franklin Institute."

By John W. Nystrom, C.E.

The Parabolic Construction of Ships is now brought to perfection. Its progress has appeared in the "Journal of the Franklin Institute,"* and I will here give the conclusive and fundamental formula for the system.

All the lines in a ship can be constructed by one simple formula, viz.:—

$$\beta = b\left(1 - \frac{y^n}{l^n}\right)^q$$



b = half the breadth.
l = length from Θ to the stem or stern.
For the frames, d, or the depth from load water-line to the keel, takes the place of l.
β = ordinate for the line.
y = abscissa.
n = exponent.
q = power of the exponent n.

This is the general formula for the Parabolic Construction. Simple as it is, it gives any line or form of ship that can reasonably be required. It will form a square, rectangle, triangle, circle, ellipse, parabola, hyperbola, cyma; all of any order or combination.

The variety of lines represented by the figure are obtained by altering the power q, while n remains constant; or any variety of lines can be obtained for each value of the exponent n.

It is here found necessary to the development of the subject, to propose or establish new names to such lines as have not heretofore been defined or subjected to an algebraical formula. The degree of development of an art may be correctly matured by the perfection of its vocabulary. As the construction of ships has not heretofore been brought to a perfect system, we have not been able to define the great variety of lines or forms of ships. We can say, a vessel is very sharp, or very full, with more or less rise of floor; but we have no language by which to convey correctly, how sharp, how full, or with how much rise of floor. As an illustration it may be mentioned, that on one occasion I met some shipbuilders, and discussed with them the construction of ships; when one said, "I am constructing a ship that will be so sharp, that you cannot roll a barrel on the lower deck, within fifteen feet of the bow," which made me no wiser. Now in the language of the Parabolic Construction, to convey the same idea with precision and accuracy, we have only to give the exponent and power, which not only impress the mind clearly with the correct degree of sharpness, but also with the complete form of the vessel.

* The previously published papers upon this subject will be found in The Artizan vol. for 1863.

We have both in Europe and America many curiously constructed vessels, and some of them reported to perform wonderfully, but we have not been able to record their peculiarities; for even the drawing of their lines would fail to convey with correctness what constitutes their novelty or folly.

It is therefore proposed to establish the following technical terms in Naval Architecture.

Any line $p\ l$, in the accompanying figure, located between the parabola p and ellipse e, to be called paralipse.

Any line $p\ c$, located under or within the parabola p, to be called paracyma. In architecture, cymas are generally constructed of circle-arcs, but in this case cymas are derived from parabolas.

Any line $e\ l$, extending outside of the ellipse, to be called evolipse.

In modern constructed vessels those lines are generally distributed as follows:—

All water-lines of the displacement are paracymas, with the highest power near the keel, approaching parabolas near the load water-line, which latter may also be a paracyma. The frames are generally paralipses about the middle of the vessel, and terminate in parabolas and paracymas, in the stern and bow. Above the water, the horizontal lines are generally parabolas in the foreship; and in the aftership, paralipses, ellipses, and evolipses.

The power q defines the line as follow:—

Parabola p $\quad \beta = b\left(1 - \frac{y^n}{l^n}\right)^{q = 1}$

Ellipse e $\quad \beta = b\left(1 = \frac{y^n}{l^n}\right)^{q = \frac{1}{n}}$

Circle, $\quad \beta = R\left(1 - \frac{y^n}{R^n}\right)^{q = \frac{1}{n}}$

Paracyma $p\ c$, $\quad \beta = b\left(1 - \frac{y^n}{l^n}\right)^{q > 1}$

Paralipse $p\ l$ $\quad \beta = b\left(1 - \frac{y^n}{l^n}\right)^{q}$ between 1 and $\frac{1}{n}$.

Evolipse $e\ l$, $\quad \beta = b\left(1 - \frac{y^n}{l^n}\right)^{q < \frac{1}{n}}$.

In a treatise on the Parabolic Construction of Ships now in progress, tables are calculated for eighteen values of the power q, each with 48 different exponents n, making 864 different lines; which will cover the most general requirement in practice.

The following is a sample of a part of one table:—

Table X. Paracymas. q = 1·25.

Exp.	Ordinates or Cross-sections.							Area or Displacement.		Cent. grav.	$\frac{2}{3}\int \beta^3\,d\,x$
n	1	2	3	4	5	6	7	a Θ D	T	e	Φ
2	·1658	·3599	·5384	·6979	·8273	·9226	·9805	·6239	·0178	·3575	·2785
2·25	·1852	·3960	·5867	·7444	·8643	·9450	·9884	·6512	·0186	·3660	·3025
2·5	·2071	·4340	·6302	·7841	·8936	·9610	·9930	·6735	·0193	·3735	·3263
2·75	·2288	·4700	·6695	·8177	·9165	·9724	·9959	·6953	·0199	·3893	·3445
3	·2505	·5041	·7047	·8463	·9344	·9805	·9975	·7164	·0205	·3850	·3615
3·25	·2712	·5362	·7364	·8698	·9486	·9861	·9985	·7333	·0210	·3904	·3774
3·5	·2918	·5664	·7658	·8908	·9598	·9903	·9991	·7474	·0214	·3954	·3930
3·75	·3121	·5949	·7903	·9097	·9685	·9925	·9994	·7605	·0217	·4006	·4064
4	·3319	·2616	·8130	·9225	·9793	·9951	·9996	·7724	·0221	·4043	·4182
5	·4069	·7128	·8822	·9610	·9908	·9987	·9998	·8099	·0234	·4179	·4564

Either table, exponent, or power can be employed for either frames, water-lines, or displacement.

$$\left.\begin{array}{l}\text{Area of any water-line } \mathfrak{a} \text{ or } a.\\ \text{Area of any cross-section } \Theta \text{ or } \theta.\\ \text{Cubic content of displacement D.}\end{array}\right\} = \int \beta\, d\, y$$

which integral co-efficient is contained in the column $\mathfrak{a}$ Θ D.

The depth of the centre of gravity of any cross-section, or of the displacement, or the distance from the dead flat Θ, to the centre of gravity of the area of any water-line, or of the fore or aft part of the displacement, will be

$$e = \int \frac{\beta\, y\, d\, y}{\mathfrak{a},\ \Theta, \text{ or D}}$$

which integral co-efficient is contained in the column e.

The height of meta-centre will be

$$m = \frac{2}{3\,\text{D}} \int \beta^3\, d\, y$$

which integral co-efficient

$$\phi = \frac{2}{3} \int \beta^3\, d\, y$$

is contained in the column ϕ.

When the power q and exponent n are given, we have—

Height of meta-centre $m = \dfrac{l\, b^3\, \phi}{\text{D}}$

Momentum of stability $= \text{Q sin. } v \left(\dfrac{l\, b^3\, \phi}{\text{D}} \mp g \right)$

Q = weight of the vessel, and g = vertical height between the two centres of gravity.

The treatise on the Parabolic Construction, now in progress, will contain fuller explanations, with practical examples and drawings, which, on account of the tables being so complete, requires no algebraical formulas in its application.

J. PICKING'S IMPROVEMENTS IN REFRIGERATORS.

The apparatus, constructed according to Mr. Picking's invention, is intended for facilitating the rapid refrigerating or cooling of wort and other liquids. The novel features in the invention may be stated as consisting in the combination together of a series of concentric rings upon a

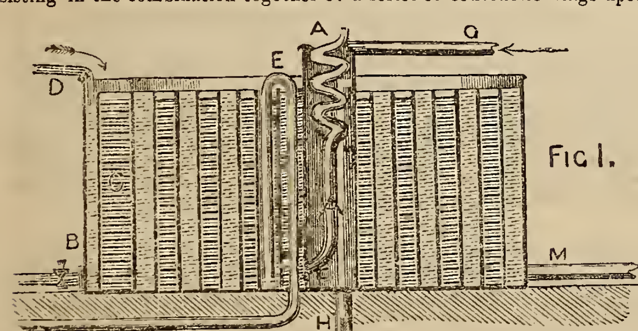


Fig 1.

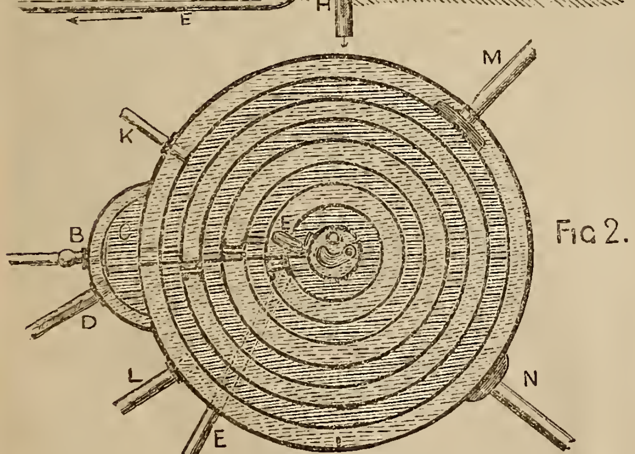


Fig 2.

base common to the whole, as shown in the accompanying woodcuts (Fig 1 being a section, and Fig. 2 a plan of the apparatus), and so forming a series of passages or spaces, around which the wort to be cooled and the cold water (or, in brewery parlance, "*liquor*") circulate in alternate passages or "ways."

The construction and action of the apparatus are both very simple; and the inventor has evidently well studied the question of how to produce rapid refrigeration without necessitating the employment of a complex or intricate apparatus. It will be seen on reference to our illustration of the plan of the apparatus (fig. 2), that a diaphragm or vertical division-plate extends from the central tube, F, to the external periphery of the apparatus; the wort to be cooled enters the apparatus in the centre through the pipe, A, which may by preference be formed spirally at the upper portion, the surrounding tube, F, forming a water or "liquor" space, which is not connected with the surrounding series of circulating water or "liquor" ways, but is kept supplied by means of the pipe, G, the overflow being taken off by the pipe, H.

The wort leaving the pipe, A, enters the first "wortway" of the refrigerator, flowing round until stopped by the vertical diaphragm, before referred to, when the current being caused to reverse, it passes by means of a circulating connection across or through the surrounding *water* or "*liquor way*" to the next surrounding "wort way," or space, and so on, the wort gradually cooling as it travels towards the outer circulating chamber or space, and the current being caused to travel from one to the other of the "wort ways" by the means just described, until it arrives at the last wort space, or that furthest removed from the centre of the apparatus, from whence it is drawn off as shown by the pipe B, from the receiver C. The cold water or "liquor" enters the apparatus through the pipe D, at the "liquor space" or "way" farthest removed from the centre of the apparatus, and is caused to travel or circulate in a direction contrary to that followed by the wort, round the series of "liquor ways" or spaces, passing from one to the other in a similar manner to that described with reference to the wort circulation, until it arrives at the one nearest the central tube F, and by means of the syphon pipe E is drawn off from the last circulating liquor passage, and passes downwards through one limb of the syphon pipe, which descends through the first "wort way" and is led away from the apparatus as indicated by the arrow.

K is an overflow pipe from the last "wort way," L is a pipe provided for a similar purpose for the last "liquor" or "water way;" M is a cleaning out pipe for the series of "wort ways;" N is a similar pipe for the series of water or "liquor" ways.

REVIEWS AND NOTICES OF NEW BOOKS.

The Orthogonal System of Hand-railing, with Practical Illustrations of the Construction of Stairs. By JOSHUA JEAYS. Second Edition. London: Simpkin, Marshall, and Co. 1864.

To the operative joiner and "staircase-hand," the labours of the late Mr. Peter Nicholson gave (amongst other useful works) a simple method for setting out and working hand-railings for stairs, and the generation of lines and methods of combining the materials employed in such constructions, so simple and easily to be understood, that Peter Nicholson's book was the standard work of reference in every wood-working establishment. Mr. Jeays found, however, that in applying the rules laid down by Mr. Nicholson for the application of the section of a cylinder to the construction of the face-moulds of a hand-rail, that the face-moulds given by him were incorrect, as the lines given as the butt-joint lines of the face-moulds were entirely out of their proper place, and consequently led to the most erroneous results. He also found that the face-mould itself given by the cylindrical section is not of the most advantageous form in point of economy that may be employed in cutting the wreath out of the plank; whereas, the construction of the hand-rail upon the orthogonal system is more economical, and the face-mould is more easily applied to the plank. The author, with the aid of eighty pages of text and ten plates, gives a very complete and practical treatise on the construction of stairs, and develops a system of hand-railing simple, economical, and upon correct principles; and it appears to us that not alone does he deserve the large silver medal awarded to him by the Society for the Encouragement of Arts, Manufactures, and Commerce, but that his book should be thoroughly well known amongst those for whose benefit it has been written.

The Operative Mechanics Workshop Companion. By W. TEMPLETON. Eighth Edition, revised and enlarged, with the addition of Mechanical Tables for the use of Operative Smiths, Millwrights, Engineers, &c. London: Lockwood and Co., 1864.

As one of the very early operative mechanics' books of reference, it has from time to time been improved, so as to keep pace, in some measure, with scientific and general progress, and the country smith, millwright, or engineer, for whose special use some additional tables, and other matter, have been recently added, will no doubt find much that is useful; but Messrs. Lockwood would be doing a good service to the class for which this book is intended if they would have it still more thoroughly revised, a vast deal that is antiquated removed and replaced with that which would be of great service to the operative mechanic, for what on earth is the value of the information upon marine engine boilers to

be found at pp. 295-296, or on locomotive boilers, to be found pp. 296-297, or of "the table of dimensions of steam engine cylinders by celebrated makers," at page 298?

Whilst there is in the present edition of Templeton's book a great deal that is useful, there is a great want of arrangement of the matter, and we also notice a jumbling up of a steam hammer advertisement between obsolete tables and rules relating to boilers, parallel motions, &c., and logarithms, &c.; added to which the printing is execrable for such a class of work, though no doubt, well enough, adapted for the Catnach class of Seven-dial's literature.

Engineers', Mining Surveyors' and Contractors' Field-book for Expediting Field-work Operations. By W. Davis Haskoll, C.E. London: Lockwood and Co. 1864.

We know of no better field-book of reference or collection of tables than that which Mr. Haskoll has given for plotting traverse surveying, and giving differences of level with corresponding horizontal distances in taking levels with the theodolite, and for setting out curves and slopes without calculation, arranged for any unit of measurement, as chains of feet, links, or metres. The book is got up in Messrs. Lockwood's usual good style, and the printing is an excellent specimen of Spottiswoode and Co.'s admirably clear typograpby, whilst it is bound in strong, serviceable style.

Railways in China. Report upon the Feasibility and most Effectual Means of introducing Railway Communication into the Empire of China; with a Map. By Sir Macdonald Stephenson. London: Printed by J. E. Adlard, Bartholomew-close. 1864.

Sir Macdonald Stephenson appears to have set about realising an important step towards the creation of "railways in the moon" by giving "The Brother of the Moon" a general scheme of railways for the Celestial Empire, by which the resources of that vast area and intercommunication between the more important parts thereof may be developed, and particularly the existing and projected lines of railways of our Indian empire may be extended and made to ramify and permeate the countries beyond the present limits of our Indian possessions. Sir M. Stephenson has selected an enormously large and unoccupied field for railway engineering enterprise; and he deserves the thanks of the nation for having done so and followed out the task to which he has devoted himself; he has given, in a collected form, succinctly a vast amount of valuable information, and which, besides having its value for the special purpose he had in view, is in aid of a vast number of other useful objects to which the intelligence of this country has been already directed.

As it is impossible to do justice to Sir M. Stephenson's report within the limits available in the pages of our monthly issue devoted to the notice of books, we advise all who take an interest in the subject to obtain a copy of the report and attentively consider the vast amount of valuable information therein contained, as it is not alone to the railway engineer, or to those interested in the introduction of railways into China, to whom the information is of interest, but to the entire nation, and we sincerely trust Sir M. Stephenson may live to see in China, what he has already seen in India—the realisation of his original projects for the introduction of railways; for to Sir M. Stephenson may properly be assigned the credit of being the father, or introducer, of railways in India.

Military Bridges, with Designs for Trestle and Truss Bridges for Military Railroads. By Hermann Haupt, A.M., Civil Engineer. Illustrated by sixty-nine lithographic engravings. New York: D. Van Nostrand, 192, Broadway. 1864. London: Trübner and Co. 1864.

In the present day, when "there are wars, and also rumours of wars," and which rumours may shortly be converted into realities, the subject of military bridges—treated by an author and professional man of acknowledged ability—acquires a greatly increased interest; and as Mr. Haupt has not limited the treatment of his subject to the giving of a few theoretical hints as to what may or might be done for bridging streams and gullies for the rapid transport of large bodies of men and materials in actual warfare, his labours will be thoroughly appreciated by the military engineers of all countries.

Memoirs of the Distinguished Men of Science of Great Britain living in the Years 1807-8, *and Appendix, with an Introduction.* By Robert Hunt, F.R.S., &c. Compiled and arranged by William Walker, jun. Second Edition. London: E. and F. N. Spon. 1864.

A very interesting collection of memoirs of men whose names will be for ever associated with one of the most brilliant eras in the history of the advancement of science in Great Britain; and whilst the work was originally undertaken for the purpose of being issued with the engraving of "The Distinguished Men of Science of Great Britain living in 1807-8 assembled at the Royal Institution," it found such an extensive sale as to necessitate a second edition, with numerous additions and the requisite revisals, &c., and the present edition is well worthy of a foremost place in every library of scientific books.

Of the great picture, designed by John Gilbert and drawn by J. F. Skill and W. Walker, and the engraving, which has been executed by W. Walker and George Zobell, we may, with the utmost truth, say we have never seen so admirable a grouping or such a thoroughly successful combination of portraits, every one of which is, we believe, faithful to the utmost degree, except, perhaps, that of Joseph Bramah, of whom it is to be presumed no facial portrait could be found, and, lacking which, the artist has introduced the figure with his back to the rest of the group. It is an admirable picture, the size of the engraving is 41in. × 21½in., and comprises fifty figures. We hope the enterprising publishers of the engraving have reaped an ample reward for the great outlay incurred.

BOOKS RECEIVED.

"Geometrical Disquisitions (the quadrature of the circle)." By L. S. Benson. London: Saunders, Otley, and Co., 66, Brook-street, W. 1864.

"Bulletin Trimestrial du Cercle des Mecauiciens Francais, Marseilles."

"Society of Engineers. Transactions for 1863." London: E. and F. N. Spon. 1864.

NOTICES TO CORRESPONDENTS.

S. (Copenhagen)—The formula you quote is perfectly consistent with the rule given by Murray. D stands of course for the *total* displacement; but y denotes only the ordinate drawn at half breadth of the loadwater line, as you will see in Murray, fig. 3, page 29. Your quotation from Murray leaves us in the dark as to what you actually mean; the rule XIV. is given at p. 44, not 45, and we find no table at page 54; but the rule XIV. is perfectly consistent with the expression

$$\frac{2}{3}\int\frac{y^3\,d\,x}{D}$$

only there is a misprint in the rule—page 140 being referred to, whereas it should be page 29. For formulæ to be worked without the aid of the integral calculus, we can recommend you Mr. Normand's little work,* which we noticed in The Artizan of May last.

A Journeyman Fitter's letter to hand on the 28th ult., was received whilst we were going to press—too late for insertion in our present issue.

P. (Greenock)—Yes; we avail ourselves of your suggestion. We shall be glad to hear from you by letter in your own language. This will doubtless afford you an opportunity of expressing yourself more clearly and comprehensively. We will write you by post on receipt of your letter.

Errata.—In The Artizan of June, Mr. Peacock's letter on Chain Cable Testing, p. 137, line 12, for "2 square inches," read ·2 *square inch;* line 13, for "2,485 square inches," read ·2485 *square inch.*

S. T.—We cannot agree with you, nor should we advise you to act in the manner you propose, which we consider would be most prejudicial to your own interests. Reconsider the subject, and if we hear from you by post to say that you have not taken active measures we will then write you explaining in detail our views upon the several points, and as to the course *we* should adopt.

RECENT LEGAL DECISIONS

AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

Under this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

Holdsworth *v.* M'Crae.—This was a action tried in the Court of Queen's Bench by one Halifax, a damask manufacturer, against another for alleged piracy of a damask star pattern, registered under the Copyright Designs Act, 5th and 6th of Victoria, cap. 100. A piece of the damask manufactured with the plaintiff's pattern or design was registered without any written claim or description, but the particulars in the action of what the plaintiff claimed as a novelty were "the particular collocation of the shaded and bordered stars on the ornamental chain surface, as shown in the registered pattern, thus forming together the ornamentation of a 'woven fabric.'" The case has been twice tried, and on both trials the jury found that both the star and combination of it in the plaintiff's pattern were new. But on the last trial a point of law was reserved, whether the registration was bad, because, a piece of the damask itself being registered without written claim, description, or specification, it could not be collected with reasonable certainty, from the article of manufacture which the plaintiff had furnished to the registrar, what the design was which he intended to register; and because the registration enabled the plaintiff at his option to claim one or other of several designs, and not one design only, applicable to "woven fabrics," in class 12, mentioned in section 3 of the Act. The Court thought that the fairest and most convenient course on the registration of a design was to register the pattern itself, which could by no means be so well described in any other way as by a drawing of the pattern or by the pattern itself. In patent cases written descriptions or specifications had led to great quibbling; and the object in the the case of designs was to obviate this difficulty in the registration of the design itself, which might be either by the drawing or the pattern, both being in substance the same. The design was an entire thing, and a man could only register one design at a time, and all that entered into it was to be taken as registered.—Judgment for the plaintiff.

Horton *v.* Mabon.—The plaintiff in this case had obtained letters patent for an alleged new invention for the improvement of telescopic gasholders. The improvement consisted, among other things, in the application of a double angle-iron cup or trough, filled with water to the points of contact between the respective cylinders of the gasometer, by which the escape of gas was prevented. Such a user of the double-angle cup was new as regards gasometers, but was well known, and had been commonly used for other purposes. In this action for infringement in making gasometers with the double-angle cup, the Court of Exchequer Chamber (affirming the decision of the Common Pleas), held that this was merely the application of a well-known instrument to an analogous purpose; that it was not a new invention; and, therefore, not the subject of a patent.

---

* "On the Application of Algebra to Shipbuilding."

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

Public Works in Paris.—The following figures represent the outlay for public works carried out in Paris at the expense of the Government since the revival of the empire 1852:—

Joining of the Louvre and Tuilleries Palaces	£2,500,000
Repairing of Historical Monuments	86,800
Palais de l'Elysée	56,000
Boulevart de Strasbourg	125,960
Boulevart de Sébastopol (right side)	940,000
Monument of Marshal Ney	2,000
Hippodrome de Longchamps	60,000
Tomb of Napoleon I.	34,600
Foreign Office	180,000
Improvements in the Ile des Cygnes	17,120
Palace of Industry	595,200
Boulevart de Sébastopol (left side)	500,000
Ponts des Invalides, d'Jéna, and d'Arcole	170,000
Notre Dame Cathedral	140,000
Public Works decreed by law of 1858	2,400,000
New Opera Building	880,000
Total	£8,687,680

Relative Effect of Different Points upon Lightning Rods.—The *Comptes Rendus* publishes the following notice, which was addressed to the Academy of Science at Paris, by M. Perrot:—"By means of an electric machine, I charged a large metallic plate representing a cloud, until a very sensitive electro meter marked 10°. I then gradually approached to the plate, first a rod rounded at its extremity, such as M. Despretz has proposed at the terminal of a lightning rod; afterwards an ordinary lightning rod point; and finally a very sharp point. These experiments gave me, as a mean, the following results:—1. The round-pointed rod remained without neutralising effect until it was struck, at a distance which I shall assume as the units. 2. The neutralising action of the common point did not begin until the distance was less than twelve units. 3. At the distance of 12 units, at which the common point had no neutralising action, the sharp point discharged the plate instantaneously. 4. The neutralising action of the sharp point began to show itself when the distance was less than 170 units. The neutralising of the fine point, therefore, extended nearly 170 times further than the striking distance, or 13 times further than the action of the common point."

A New Light.—The magnesium light is richer in actinic power than any other artificial light known—is so rich, indeed, in chemical rays, that the sun itself, when unobscured by fog or cloud, exceeds only by 34 times the chemical power of a magnesium flame having the same apparent diameter as that which the sun presents. The result is that by the light produced by the combustion of magnesium, wire, such as is now being sold at 3*d*. a foot, we are able to obtain, in any weather, and at any hour of the day or night, much better photographs than can ever be obtained in this country by sunlight, except on such clear and sunny days as occur in this country but very rarely, indeed. Magnesium will thus render us henceforth independent of the sun for photographic purposes, and will, moreover, enable us to obtain photographic pictures of places, such as the interior of caves and mines, the passages in the interior of the Egyptian pyramids, and the like, into which the sunlight never enters, nor can enter. But it is not in actinic power alone that the magnesium light exceeds all other artificial lights yet produced. For the purpose of artificial illuminations, it is without a rival. A very thin magnesium wire will give off, in burning, as much light as a very powerful electric light, is soft and diffusive, and does not in the least dazzle or pain the eyes. It is, moreover, of the purest white, so that all colours, even to the most delicate tints, are seen in it as perfectly as in sunlight, while a magnesium lamp has over both the electric lamp and the ordinary gas light the advantage that it can be carried about as readily as a candle. A still greater advantage—one, indeed, of immense importance—which the magnesium light has over gas, and over any kind either of oil-lamps or of candles, consists in the circumstance that magnesium, in undergoing combustion, gives off no deleterious vapours, nor, indeed, any vapours of any kind. Instead of its burning, as gas, candles, and oil do, into aqueous vapour and carbonic acid, with a greater or less admixture of sulphurated hydrogen, and other furniture-destroying, plate-tarnishing, and health-injuring compounds, the only product of the combustion of magnesium is a harmless solid—the oxide of magnesium, or magnesia. All this points to the magnesium light being likely to come extensively into domestic use, while its great brilliancy would seem to render is eminently adapted for use in lighthouses. In all probability its price will not long be an obstacle to either of these two applications of it; for even now, while the manufacture of magnesium is not yet three months old, the light from magnesium is but little more costly, quantity for quantity, than that from "composite" candles, seeing that two and a half ounces of magnesium will give forth, during combustion, as much light as 20lb. of the best stearine.

The Junction-road Out-fall at Brighton.—The Junction-road Out-fall, which receives the main sewage of this town, has been lengthened by 300ft. This length of piping had been previously joined together on the higher part of the beach in front of the Chain Pier Esplanade. The piping weighed 60 tons. The beach being an inclined plane down to the sea, the huge mass would have descended by its own weight over the planking prepared for its passage to the sea. But it was necessary to regulate and guide its descent; and this was effected by means of several windlasses fixed on the beach, and which held the piping by strong ropes. No joint of the 300ft., it is said, was strained. It was then towed to the bed prepared for it at at the extremity of the piping laid last year, and sunk to its destined resting-place. Divers were employed in this. An escape had to be found for the air in the piping, and this was effected by means of tubes coming to the surface, whilst the water was let in by the removal of screw-plugs. The piping was thus safely lowered into its exact position, without a flaw, and joined to the end of the out-fall. There are now 900ft. of the out-fall laid down, and 850ft. remain to be laid. This will be done in three more lengths. So far as can be ascertained by a partial operation, the experiment of this out-fall, in taking the sewage of the town out into deep water is said to have been quite successful.

Another Exhibition in Dublin.—The Dublin Winter Garden Company intend to celebrate the opening of their spacious building, now in course of erection, in the Cobourg Gardens, by an International Exhibition, which is to commence next May, and remain open for about six months. The exhibition will include manufactures, raw materials, fabrics of all kinds, machinery, the fine arts, &c. When the exhibition has been closed the building will be opened as a permanent exhibition, somewhat upon the principle adopted at Sydenham.

Large Fireproof Safe.—One of the largest safes constructed has been completed by Messrs. Chubb and Son for an Indian bank. It is 14ft. long, 10ft. deep, and 8ft. high, and is of the enormous weight of 17 tons. Small cash safes, secured by detector locks, are fitted to the interior, and the outer doors are fastened by four locks, throwing twenty-seven bolts.

Meynard's Steam and Fluid Regulator.—This invention consists in combining electrical and mechanical apparatus with a valve, tap, louvre, or similar appliance, in such manner that a variation in the pressure, or other effect or condition of the fluid to be regulated, shall make or break electric contact, and thereby regulate the valve. This may be effected thus for working throttle valves. The rise and fall of mercury in the pressure gauge sends and interrupts the electric current by wires, inserted into its tube and communicating with an electric magnet, which attracts and releases an armature on a beam, carrying drivers, which are in gear with ratchet wheels toothed in opposite directions, on an axis in gear with the spindle of the throttle valve. The electro-magnet and beam are on a frame, driven to and fro by an eccentric, worked by the steam-engine. According as the armature is attracted or released, one or other of the drivers will be put in gear with one of the wheels and their axis, and hence that of the valve worked in a corresponding direction.

Ships Paid-off and Ships Commissioned.—Returns which have been laid before Parliament show that in the financial year 1862-63 51 ships and vessels of 74,363 tons in all were paid off; the cost of repairs done to them during the year was £63,907. In the same year 78 ships and vessels of 93,195 tons were commissioned; the expenditure incurred upon them in the year amounted to £556,814. 335 vessels of 404,358 tons were in reserve upon which there was expended in the year £417,415, chiefly in preparing some for commission; there were a few more in reserve upon which no expenses at all were incurred. In the next financial year, 1863-64, 49 ships of 83,094 tons were commissioned, and 40 of 48,841 tons paid off. It is estimated that 65 of 75,060 tons will be paid off in the current financial year 1864-65. and replaced in commission by others. The estimated expenditure of this year of ships in commission is £127,402, and on ships in reserve £326,920.

Bills Passed.—The Royal assent has been given by commission to the following Bills:—The Customs and Inland Revenue Bill, Charitable Assurance Enrolments, Land Drainage (Provisional Order), High Court of Chancery (Despatch of Business), Promissory Notes and Bills of Exchange (Ireland), Joint Stock Companies (Foreign Countries), Under-Secretary's Indemnity, Registration of Voters (Scotland), Local Government Supplemental, Naval Agency and Distribution, Naval Prize, Naval Prize Acts report, Chain Cables and Anchors, Common Law Procedure (Ireland), Insane Prisoners Act Amendment, Court of Justiciary (Scotland), Pontypridd Water, Bedford Gas, Chelsea Water, Clifton and Hampden Bridge, Stroud Gas, Swansea Harbour Trust, Wellington (Salop) Markets, Andover and Chilton Pond Road, Thomset Road, Deal and Walmer Gas, Drogheda Water, Ashton-under Lyne and Staleybridge Water, Lynvi Valley and Ogmore Valley Railway, Chichester Harbour Embankment, North Eastern Railway (York and Doncaster Branch), Pucklechurch Roads, Greenwich and South-Eastern Docks, Newport Turnpike Trust, Portmadoc and Beaver Pool Road, London Necropolis and National Mausoleum, Hertford Gas, North East Lancashire, and Yorkshire and West Yorkshire Railway, Cowes and Newport Railway, Brough Ferry Road, Caledonian Railway (Bredisholm Branch), Holborn Valley Improvement, Bedford and Cambridge Road, Stirling Water, Salop Fire-office, Trent, Ancholme, and Grimsby Railway, Westminster Palace Hotel, North-Eastern Railway (additional powers), Scarborough Valley Bridge, Rock Life Assurance, Belfast and Northern Counties Railway, Chesterfield and Heruston Railway, Chichester and Midhurst Railway (No. 3), Moira and Gressley Road, North Western Railway, East and West Junction Railway, South Yorkshire Railway and River Dun Company, Liverpool Imperial, Liverpool Sanitary, Workington Harbour, Manchester, Sheffield, and Lincolnshire, Tendring Hundreds Railway, Edinburgh and Glasgow and Alva Railways, Ulverstone Gas, Wrexham Water, Ely, Haddenham, and Sutton Railway, London and South-Western (Chertsey Extension), Salisbury and Yeovil Railway, South Staffordshire Water, West Norfolk Junction Railway, West Riding and Grimsby Railway, Scottish North-Eastern and Alyth Railway, Scottish North-Eastern and Perth and Almond Valley Railways, North British Railway (Abbey Holm branch), Kent Coast Railway, Crystal Palace and South London Junction Railway, Great Eastern Railway (High Beech Branch), London, Chatham, and Dover Railway (No. 3), Oswestry, Ellesmere, and Whitchurch Railway (No. 2), South-Eastern Railway (No. 1), South-Eastern Railway (No. 3), Whitney Railway, North British Railway (Perth branch), North Cheshire Water, Newcastle-upon-Tyne and North Shields Roads, Mytholm Royal Bridge and Blackstone Edge Road, Denham Valley Railway, Dublin, Wicklow, and Wexford, Railway, Lancashire Local Board of Health, North and South Western Junction Railways, Nottingham Gas, Okehampton Railway, Scottish North-Eastern and Scottish Central Railway, Stockton and Middlesborough Water, London and Liverpool Fire and Life Insurance, Ribblesdale Railway, Down Docks, Lymington Harbour, Whitehaven Water, Newcastle-under-Lyne Canal and North Staffordshire Railway, Wallasey Embankment, Shrewsbury-bridge, East Norfolk Railway, London, Brighton, and South Coast Railway, Railway Passengers' Assurance Company.

NAVAL ENGINEERING.

Trial of the Iron-clad "Enterprise."—The official trial of the iron-clad steamer *Enterprise*, one of the class of wooden armour-plated vessels designed by Mr. Reed, the Constructor of the Navy, to decide whether wooden ships considerably smaller than the *Royal Oak* and *Prince Consort* type of armour-clads, cannot be coated with shield armour-plates of 4½in. in thickness, and rendered as effective as our larger armour-plated vessels, took place near the Nore with most satisfactory results, on the 26th May. As originally designed it was calculated that she would draw 12ft. 9in. forward and 15ft. 3in. aft, or a mean draught of 14ft., but during her trial she drew only 11ft. 10in. forward, and

15ft. 8in. aft. The *Enterprise* is driven by a pair of horizontal single piston-rod engines, fitted with surface condensers, tubular boilers, super-heaters, and all the latest improvement. Her machinery was supplied by Messrs. Ravenhill, Salkeld, and Co. The engines are of 160 horse-power (nominal), but are capable of being worked up to four times that power. The screw is a two-bladed Griffiths, with a diameter of 11ft. 8in., and a pitch of 11½ft. The diameter of the cylinder is 45in., and the length of stroke 18in. There is an area of fire-grate surface of 96ft., and of heating surface 960ft. On reaching the Lower Hope Reach six runs were made at the measured mile, with full boiler-power, with the following results:—First run—Time 7min. 40sec., revolutions of engines, 98, speed 7·826 knots, pressure of steam 23½lb., vacuum 26. Second run—Time 5min., revolutions of screw 99, speed 12 knots, pressure 22½, vacuum 26lb. Third run—Time 6min. 32sec., revolutions 98, speed 7,965 knots, pressure 22lb., vacuum 26½. Fourth run—Time 5min. 3sec., revolutions 100, speed 11·881 knots, pressure 22½lb., vacuum 26¾. Fifth run—Time 7min. 26sec., revolutions 97, speed 8,072 knots, pressure 22lb., vacuum 26½. Sixth run—Time 5min. 8sec., revolutions 100, speed 11·688 knots, pressure 22lb., vacuum 26. Taking the first means of the above runs we have a speed in knots of 9·913, 9·982, 9·923, 9·976, and 9·888; and the second means as 9·880, 9·952, 9·949, and 9,928, giving the true mean speed of the vessel as 9·927 knots, or a trifling fraction under 10 knots per hour. At the termination of the runs at full speed four runs were made over the measured mile at half boiler power, with the following results:—First run—Time 6min. 27sec.; speed, 8·022 knots; revolutions 80; pressure 19lb.; vacuum, 26. Second run—Time 8min. 54sec.; speed, 9·363 knots; revolutions, 80; pressure, 19½lb.; vacuum, 26½. Third run—Time, 8min. 56sec.; speed, 6·716 knots; revolutions, 81; pressure, 19lb.; vacuum, 26. Last run—Time, 6min. 19sec.; speed, 9·499 knots; revolutions, 81; pressure, 19½lb.; vacuum, 26½. The average speed at half-boiler power was 8·105 knots. Some experiments were then made with the view of ascertaining the steering and turning capabilities of the *Enterprise.* The screw well being abolished, the principle of the old gun-room tiller has been reverted to with the most satisfactory results. The tiller is placed below the armour-plates, which altogether prevents its being shot away, and an arrangement is also effected by means of which the frigate can be steered from the armour-plated battery, whereby the steersmen are effectually protected. With four men at the wheel the helm was brought over to starboard, at an angle of 30 deg., and the full circle made in 4min. 14sec. from a state of rest, and in 4min. from full speed. The circle to port, with three turns of the wheel and the rudder at an angle of 29 deg., was accomplished in 4min. 18sec. from full speed, and in 4min. 37sec. from rest. From the circumstance of the chief weight of the vessel being placed amidships the *Enterprise* possesses remarkable powers of turning, and during the trials the full circles were made in little, if at all, more than a diameter of twice the vessel's length.

THE "SALAMIS," paddle-wheel despatch vessel, 835 tons, 250 horse-power, having taken in coals on the 7th ult., was taken to Maplin Sands for trial of her machinery. With a draught of water 4ft. 10in. forward; aft, 10ft. 5in.; pressure of steam, 25; vacuum, 26½; revolutions of engines, 33, a speed of 13·689 knots per hour was obtained at full boiler power. At half boiler power the main speed was 11·371 knots. The vessel is fully rigged, with all the necessary sea stores on board; her armament is also complete. She is fitted with patent paddle-wheels and Morgan's feathering floats. On trial the immersion of the upper edge was 1ft. 2½in. The engine was stopped from the time of moving the telegraph, in 22 sec.; started ahead in 30 sec.; and astern in 30 sec. The temperature was taken at 2 and 4 o'clock. At 2 o'clock it was on deck, 64; in the engine-room, 79; in the forward stokehole, 94; and in the after stokehole, 91½. At 4 o'clock p.m. the temperature was on deck, 64; in the engine-room, 80; in the forward stokehole, 75½; and in the after stokehole, 93. The force of wind during the trial was from 3 to 4, and the sea was smooth. The trial was pronounced to be in every respect satisfactory.

TRIAL TRIP OF THE "SHARPSHOOTER."—The *Sharpshooter*, 6-gun screw sloop (iron), of 503 tons measurement and 160 horse-power of engines, was tried on the 17th ult. at the measured mile in Stokes Bay, to ascertain her rate of steaming prior to being commissioned, and was afterwards tested in her steering powers with Capt. F. Warren's patent auxiliary bow rudder, with which she is fitted in addition to the ordinary stern rudder. She has been lined internally with the "Spence's patent preserving cement," and externally she has been payed over below the water-line with several rival pigment compositions intended for the preservation of the ship's bottom under water, so that, altogether, she may be looked upon as an experimental ship. Her armament consists of one 40-pounder rifled gun on the forecastle, one 58cwt. 6in. smooth bore aft, and four 23cwt. 6in. smooth bores for broadside service. Her draught of water was 11ft. 2in. aft and 11ft. forward. She was complete in armament, rigging, and stores. Her propeller is a left-handed "Griffiths." Six runs with full boiler power were first made over the mile, with the following results, in knots:—1st run, 8·430; 2nd, 9·113; 3rd, 8·823; 4th, 8·675; 5th, 9·600; 6th, 8·571; mean speed of the ship, 8·945 knots. The maximum number of the engines' revolutions was 100, and their minimum number 97½. The temperatures on deck and below were as follows:—1st run, on deck, 58 deg.; in engine-room, 71 deg.; in stoke-hole, 90 and 96 deg.; 6th run, on deck, 64 deg.; in engine-room 74 deg.; in stokehole 94 and 98 deg. Two runs were afterwards made with half-boiler power, the first giving the ship a speed of 8·551 knots, and the second 6·990 knots, the mean of the two being 7·770 knots. The pressure of steam was 20lb., and the vacuum was at 25in. maximum, and 22½in. minimum. The trials of speed having been brought to a conclusion those of the rudders commenced. The stern rudder was first tested to port and starboard with full boiler power, and then in the same direction with half boiler power. With the rudder hard to port it was hove up (five men being at the wheel throughout these tests) in 30 sec. to an angle of 33 deg., the half-circle being completed in 2 min., and the full circle in 3 min. 53 sec. The revolutions of the engines were 99 at the commencement, bringing up to 93 before the circle was completed. With the rudder hard to port it was next hove over to 29½ deg. of angle in 30 sec., the half-circle made in 2min. 10sec., and the full circle in 4 min. 19 sec. The revolutions of the engines, as before, were from 99 to 93. With half-boiler power the rudder was hove over to an angle of 38 deg. to port in 22 secs., the half-circle made in 2 min. 15 secs., and the full in 4min. 22secs. The revolutions of the engines were from 87 to 82. In the second trial, at half-boiler power, the rudder was hove over to an angle of 30 deg. to starboard in 26 secs.; the half-circle made in 2 min. 25 sec., and the full in 4 min. 55 sec. The revolutions of the engines were the same as in the last trial to port. Half-boiler power still was kept in use, and two trials similar to the last were made next, but now with both rudders (stern and bow) in use, with the following results:—Hard to starboard: Angle of stern rudder, 30¼ deg.; ditto, bow rudder, 39½ deg.; half-circle made in 2min. 17 sec.; full circle made in 4 min. 49 sec.; revolutions of engines, 86 to 81. Hard to port: Angle of stern rudder, 38 deg.; ditto, bow rudder, 40 deg.; half-circle made in 2 min. 4 sec.; full circle made in 4 min. 6 sec.; revolutions of engines from 86 to 81. Steam was next still further eased down, and the vessel going "very easy" ahead, two circles were made with the engines going 50 revolutions at starting, the first being to starboard, the angle of the bow rudder being 40 deg., that of the stern 30¼ deg. The half circle was made in 4min. 34sec., and completed to the full in 9 min. 8 sec. The second was to port, the angle of the bow rudder being 39½ deg., that of the stern 38 deg., while the half-circle was made in this instance in 4min. 3 sec., and the full in 8 min. 20 sec. The engines in both instances slackened in their revolutions from 50 to 47. The ship was next put ahead at full boiler power and speed, and both rudders again brought into play. In the first circle made under these circumstances, the stern rudder was hove to starboard at an angle of 30 deg. and the bow rudder to 39½ deg., the half-circle made in 2min. 4sec., and the full in 4 min. 9 sec. The engines started at 95 revolutions, and slackened down to 91. In the second circle the stern rudder was hove to port to an angle of 38 deg., and the bow rudder to 40 deg., the half-circle being made in 1 min. 51 sec., and the full circle in 3 min. 38 sec. The engines started at 96 revolutions and eased down to 91. This was the last experiment with both rudders, and several others followed with the bow rudder alone acting, but only two of these were noted, as it was evident the vessel was not sufficiently deep in the water forward to allow the bow rudder to fully develop its powers. These two circles were made with the following results:—1st. Astern at full speed, and the rudder hard to starboard, the half-circle was made in 5min. 18sec., and the full circle in 8 min. 17 sec. 2. Astern at full speed, and the rudder hard to port, the half-circle was made in 9 min. 30 sec., and the full circle in 13 min. 33 sec. The officials on board had no means at their command of accurately measuring the circles made, but it was clear that their area made under the influence of both rudders was less than with one rudder, and the time was also rather less.

NAVAL APPOINTMENTS.—The following appointments have taken place since our last:—J. Ashley, Chief Engineer to the *Orontes*, vice Roberts, superseded; F. H. Hermann, Engineer, to the *Asia*, for hospital treatment; G. Wynhall, Engineer, to the *Orontes*; P. Robertson, of the *Edgar*, confirmed as Engineer; T. Wilmott, of the *Pembroke*, promoted to First-class Assist.-Engineer; C. Beal, Chief Engineer, additional, to the *Asia*, for the *Arrogant*; H. Knight, Engineer, to the *Fisgard*, for the *Landrail*; J. Dalton, Engineer to the *Hawke*, for the Tenders; J. Crew, Supernumerary in the *Asia*, promoted to First-class Assist. Engineer; and W. J. Ray, Acting Second-class Assist. Engineer to the *Asia*, as Supernumerary. C. A. Walmsley and W. Brimacombe, Acting Second Class Assist. Engineers, to the *Asia*, as Supernumeries; G. Mackay, Second Class Assist. Engineer, to the *Indus*, as Supernumary; T. W. Sanders, of the *Farrier*, and C. K. Lacy, of the *Liverpool*, promoted to Acting Engineers; J. Murdock, Assist. Engineer, to the *Racoon*; E. Lilley, Engineer, to the *Cordelia*; M. Lambert, Engineer, to the *Racer*; F. T. Elliott, to the *Fawn*; E. Ramsay and C. Boddington, Assist.-Engineers, to the *Cordelia*; T. Summers (B) and C. J. Edge, Assist.-engineers, to the *Racer*; J. Hancock (a) and S. Gundry, Assist.-Engineers, to the *Fawn*; D. Robb, promoted to Chief Engineer, and appointed to the *Cumberland*, for the *Serpent*; J. Rollinson, promoted to Chief Engineer, and appointed to the *Cumberland*, for the *Terrible*; J. Downes, promoted to Chief Engineer, and discharged on half-pay; J. P. Allen, promoted to Chief Engineer, and reappointed to the *Harrier*; M. Murray, Engineer, to the *Excellent*, for the *Stork*; and J. C. Gray, Engineer, to the *Cumberland*, for the *Bulldog*.

TRIAL OF THE "OCEAN."—The contractors' trial of the engines of the screw steam frigate *Ocean* took place outside Plymouth breakwater on the 25th ult. Her keel was laid at Devonport in August, 1860, for a wooden line-of-battle ship, to carry 100 guns, but on the 30th of June, 1861, she was ordered to be "converted" into an iron-cased frigate, mounting 34 guns. The *Ocean* was accordingly lengthened 20ft. amidships; her stem and stern being altered. She was launched on the 9th of March, 1863, and has since been protected with iron plates and fitted with bilge pieces at Keyham. Her engines and machinery, built by Messrs. Maudslay, Sons, and Field, are precisely like those of the *Prince Consort*, with the exception only that the pitch of the *Ocean's* screw is 22ft. 6in., while that of the *Prince Consort* is 25ft. The weather was fine, wind being from the N.N.W., with a force of from 4 to 5. The sea was moderately smooth. The temperature in the stoke-hole was about 100, and on deck 65. Under full boiler power the mean of six runs at the measured mile gave 12·895 knots; revolutions, 58 per min.; vacuum, 55½. Under half boiler power the mean of four runs was 10·691 knots; revolutions, 47½; vacuum, 26½. These results are considered sufficiently satisfactory to prevent the necessity of any further trial. There were no hot bearings, and all the machinery appears to be in perfect order.

TRIAL TRIP OF THE "ROYAL SOVEREIGN."—On the 23rd ult. this vessel made her official trial of speed and power at the measured mile at Stokes Bay. The following is a summary of the results:—On the *Royal Sovereign* steaming out of harbour for Spithead it was found her draught of water was 21ft. 2in. forward, and 24ft. 10in. aft, her topsides (not measuring her iron bulwarks, but from the top of her side armour plating to the water line) being 7ft. 6in. out of water amidships. Her engines were kept at slow speed until passing the Channel Fleet at Spithead, when full steam was put on and the ship put through her runs at the measured mile with full and half boiler power with the following results:—

FULL POWER.

No. of Runs.	Revolutious of engines per Min.	Observed Time.	Speed due to Time in Knots.	1st Mean Speeds.	2nd Mean Speeds.
1	52	5m. 10s.	11·613	—	—
2		5m. 38s.	10·651	11·132	—
3		5m. 18s.	11·321	10·986	11·059
4		5m. 43s.	10·495	10·908	10·947

True mean speed 11·006 knots.

HALF POWER.

1	42	5m. 59s.	10·027	True mean Speed.	8·171 knots.
2	42½	9m. 0s.	6·315		

In the most successful trial the ship made as an unmasted three-decker just fitted with her new machinery she realised with full-boiler a speed of 12·252 knots, but it was a calm, and her draught of water was only 18ft. 8in. forward and 21ft. 9in. aft. This gives an increased immersion of the ship of fully 3ft., and the ship had also to contend against a strong westerly breeze, whereas on her three-decker trial it was a calm. Allowing, therefore, for the ship's increased immersion, and the difference in the weather, the difference in the ship's speed is satisfactorily accounted for, although an additional half knot might have been attained, but for the defective draught in the fires, which admitted of a pressure of 17lb. of steam being obtained instead of a full 20lb. This defect will be at once remedied by lengthening the funnel 12ft. The ship was next tested in making circles, to ascertain her turning powers, with full and half boiler power, with results as follows:—Full-power.—To port, with ordinary wheel on deck.—Helm got up in 1 min., to an angle of rudder of 16½ deg. The half circle made in 3 min. 21 sec., and the full circle in 6 min. 35 sec. Revolutions of engines 52 to 49. To starboard.—Helm got up in 50 sec., with an angle of rudder 20½ deg. The half circle made in 3 min. 30 sec., and the full circle in 6 min. 51 sec. Revolutions of engines as before. Half-power, with ordinary wheel on deck.—To starboard.—Helm got up in 1 min. 30 sec., with the rudder to an angle of 24 deg. The half circle made in 4 min. 9 sec., and the full circle in 7 min. 34 sec. Revolutions of engines 38 to 36. Half-power, with pilot-house wheel, which is fitted with multiplying power.—To port.—Helm up in 1 min. 30 sec., with the rudder at an angle of 40½ deg. The half circle made in 3 min. 8 sec., and full circle in 6 min. 4 sec. To starboard—Helm up in 1 min. 10 sec., with the rudder at an angle of 39 deg. The half circle made in 3 min. 16 sec., and the full circle in 6 min. 34 sec. The revolutions of the engines were in both instances from 38 to 36. There is a remarkable difference shown here in the angles

of the rudder obtained with the two wheels, being no less than 40½ deg. by the pilot-house wheel against 16½ deg. obtained by the ordinary wheel on deck. The diameter of the circle made by the ship was much less with the pilot-house wheel in use than it was with the deck-wheel in use. The temperatures were—during the first run at the measured mile—on deck, 64 deg.; engine-room, forward, 66 deg., aft, 67 deg.; stoke-hole, fore part, 108 deg., middle, 102 deg., after part, 72 deg.; 4th run at the measured mile—on deck, 66 deg., engine-room forward 68 deg., after part 72 deg. Stoke-hole, forepart, 108 deg.; middle, 112 deg.; after part, 81 deg. On the following day the experiments were resumed with the following result:—Two experimental circles were first made with the pilot-house wheel, the first being made to starboard, with twelve men at the wheel, and the rudder hove over to an angle of 24½ deg. in sec. The half circle was made in 3 min. 5 sec., and completed to the full circle 6 min. 49 sec. The second circle was made to port, and the rudder was hove over to angle of 21½ deg. (12 men at the wheel as before), in 1 min. 10 sec. The half circle was ade in 3 min. 1 sec., and the full circle completed in 5 min. 54 sec. In the first circle the heel had 6½ turns, and in the second 7 turns. The diameter of the circles was apparently bout three times the vessel's length. The ship was next placed in the channel between the Norman and Dean shoals, and, stern way having been got on her, her starboard bower anchor was let go in 17½ fathoms, and the cable veered to the fourth shackle at the hawse-pipe. The chain was then unbitted and brought to the steam capstan on the 'tween decks, and the anchor hove up again. The object of doing this was, on the part of the officials from the dockyard, merely to test officially the powers of the steam capstan. The port anchor was afterwards let go, and weighed again in the ordinary manner with capstan bars by the crew, exhibiting, however, very clearly the superiority of steam power for the purpose. A fear had been expressed that the shackles would not pass round the capstan so securely as the links of the cable, and, to test them fully in this manner, they were passed round both vertically and horizontally. They "bit" well in both positions, but it required care to deliver the chain safely off the capstan and round the rollers. The cat and fish gear for securing the anchors, novel of their kind, like all the other deck fittings of the ship, were next tested in their turn, and it was found that, with a few slight modifications, they will answer their purpose admirably. The steering gear fitted to the pilot-house has a lead of four-fifths the length of the ship to the rudder-head aft, and under such circumstances neither ropes nor chains fitted in the ordinary way could convey the whole of the work of the wheel to the rudder. To meet adequately a contingency of this kind, the ship's pilot-house wheel is connected with the rudder by metal bars forward and a disc aft, the result being that there is no "give" of rope or chain, while the disc imparts the full amount of the force created by the wheel to the head of the rudder. This is stated to be an improvement on a plan somewhat similar to the one fitted on board the mail steamer *Adriatic* by one of the shipwright officers of Portsmouth Dockyard.

MILITARY ENGINEERING.

The Mackay Gun.—A successful trial with the above gun has taken place on Crosby Beach, near Liverpool. "There were three shots fired—one to show its power against the *Agincourt* target, another to ascertain the amount of ricochet, and the third to try its range. The gun and target occupied the same position which they did on the occasion of the previous trials, the range, it will be remembered, being 200 yards. The supports behind the target had been renewed, and the *Agincourt's* side appeared as strong as ever, with the exception of the perforation made in the bottom plate at the previous experiments. The gun was charged with 30lb. of powder and a steel bolt of 153lb. in weight, manufactured by Messrs. Thomas Firth and Son, of Sheffield. Having been 'laid' by Mr. James Mackay, all present had to go under cover of a shed behind the sandhills to avoid accident, and the gun was fired in the ordinary way, but with a lengthened cord. The report was not near so loud as might have been expected, considering the size of the gun and the work it accomplishes. Upon examination it was found that a piece forced out of the outside plate was rather larger than that at the last experiment, which was 90lb. After going through the outer plate and splintering the teak the bolt smashed the inner skin, making in it an irregular hole twenty-three inches the widest way and seventeen inches the narrowest. One corner of the projectile caught one of the angle irons running up behind the target, and beat it back, moving the whole of the upper plate with its supports about two inches. The striking against the angle iron altered the course of the bolt, which went about 185 yards beyond the target in a north-westerly direction. The piece forced out of the outer plate of the target was found about 125 yards from the target, nearly in a direct line with the target and gun. The projectile was found to be badly cracked all round, and there was a piece three or four ounces in weight chipped off on one side where it had struck the angle iron of the target. It was originally 12in. in length, but by striking the target was reduced to 10½in., the round end being flattened. There seemed to be much difference of opinion as to whether the shot was a good one, the previous projectiles not having suffered to anything like the same extent. The piece which had been chipped off was found in the iron of the target. In fact the bolt was in such a state that Mr. James Mackay expressed his surprise that it had gone through the target at all, and much more that it had committed such havoc. The hole in the outer plate measured 9½in. one way and 9¾in. another way, and the piece which was forced out was about 100lb. in weight. The next experiment was to ascertain the ricochet of the bolt. The gun was charged with 2lb. of powder and a cast-iron projectile 118lb. in weight, the gun being raised to an elevation of 2½ degrees. The shot first touched the ground 325 yards from the gun, when it bounded up and touched the ground 120 yards further. Rising once more it went a further distance of 60 yards, when it again touched the ground and bounded along for 590 yards, the total distance, with only 2lb. of powder, being 1,095 yards. The gun was then loaded for the third experiment to try its range. It was charged with 25lb. of powder, and at an elevation of twelve degrees a cast-iron bolt about 9½in. in length and 130lb. in weight, was sent 3,735 yards before it touched the ground. At the point where it dropped there was a large hole, but the bolt doubtless went a considerable distance further. It was not, however, found."

Experiments at Shoeburyness.—On the 17th ult. the last but one of the series of experiments which have been conducted at this practice-ground by the members of the Iron-plate Committee was made. The target, which was 20ft. by 9ft., was constructed after the pattern of the *Lord Warden*, and represented the ordinary broadside of a wooden ship armour plated, with the addition of an iron skin outside the frame timbers. These frame timbers were of English oak, 12½in. thick, strengthened by connecting diagonal iron riders or bands 6in. wide by 1¼in. thick. Outside this came the inner planking, 8in. thick, and then a complete casing of wrought iron, 1½in. thick. Outside this casing again was 9in. of oak, which was again protected by rolled armour plates, 4½in. thick by 20ft. long and 4ft. wide. Thus the total thickness of the target was 35½in., of which 6in. were iron and 29½in. oak. In addition to this mass there were four oak deck beams averaging 15in. by 15in. square, and a massive iron knee to each beam weighing nearly 4cwt. The armour-plate bolts were 2½in. in diameter, and the beams which represented the upper and lower deck, and which were 4in. thick, and laid longitudinally along the back of the target, gave additional stiffness to the whole. There were six guns in position opposite the target, all made on Sir William's coil principle, and rifled on his shunt plan, which threw steel shot from 100lb. to 300lb. weight, and were fired with charges varying from 25lb. to 50lb. of powder. The following was the result of the numerous rounds:—*The first round.*—Service 68-pounder, steel shot, 16lb. charge. The shot produced an indent of 3·6in., striking the head of an armour bolt, and starting a bolt in the rear. No one on board the ship would have been injured; therefore the *Lord Warden* may be said to be proof against the 68-pounder fired, not with cast-iron shot, but with steel shot. The velocity of the shot was 1,500ft. per second.—*The second round.*—Somerset, 9·22in. 6½ ton gun, steel round shot, weighing 100lb.; charge, 25lb. The shot struck at the waterways, where the target presented an aggregate thickness of 42½in., passed through the outer armour-plate, and embedded itself in the backing. The waterway, 15in. by 15in. beam, was cracked through, but there were no splinters. This was a shot in the strongest part of the ship, and showed that a ship of even 42½in. thick would in time be smashed by the 6½ ton 9·22in. Somerset. The velocity of the shot was 1,540ft. per second.—*The third round.*—Somerset, 9·22in. 6½ ton gun, steel shell, weighing empty 171lb.; charge, 20lb.; and bursting charge, 7lb. The effect was not much greater than before, the outer plate being passed, the woodwork cracked right through, and the armour-plates started. Beyond starting the armour-plates the shell effect was nothing; no setting fire. The fire of the shell and the fragments darted straight from the target towards the battery. The velocity of the shell was 1,200ft. per second.—*The fourth round.*—Frederick, 7in. 6½ ton gun, steel shot, weighing 100lb., charge 25lb. The shot struck near the top of the target, and was repelled by the inner armour-plate. The Somerset made the larger hole, the hole of the 9·22in. against the 7in., with the same charge of powder, and exhibited the greater penetrative power. In other words, the large bore beat the small bore with the same charge and the same weight of gun. The upper deck beam was now started. The velocity of the shot was 1,560ft. per second.—*The fifth round.*—Armstrong, 11¾ ton, 10·5in. gun, 150lb. steel round shot; charge, 50lh. The shot was buried in the backing, knocking out the inside planking considerably, but not to the extent of occasioning serious casualty from splinters. The velocity of the shot was 1,600ft. per second.—*The sixth round.*—Anderson gun factory, 12½ ton, 9·22in. gun, 220lb. steel shot; charge 44lb. This shot passed right through the target, but at its weakest part, namely, on the top of the shelf below the upper deck beam, where the thickness is only 27½in. instead of 37½in. and 42½in. elsewhere. Such a result was necessarily unsatisfactory to every one. The velocity of the shot was 1,460ft. per second.—*The seventh round.*—Somerset, 9·22in., 6½ ton gun, 168lb. chilled cast-iron shot; charge, 25lb. The shot passed through the outer armour plate, shaking the target well behind, but without splinters. As a cast-iron shot this was a great success. The velocity of the shot was 1,540ft. per second.—*The eighth round.*—Anderson gun factory, 12½ ton gun, 221lb. steel shot; charge 30lb. This shot was fired low and grazed the ground in front, passing through the outer plate at the bottom. Practically the shot was thrown away. The velocity of the shot was 1,260ft. per second.—*The ninth round.*—Armstrong, 11¾ tons, 10·5in. gun, 301lb. steel shot; charge, 45lb. This was a most destructive shot, passing right through the whole structure, filling the deck with heavy splinters, and throwing an iron knee of 3cwt. 2qrs. 21lb. a distance of 20 yards. The shot, after passing through the target, struck an immense granite block and broke into four pieces, one of the pieces bounding off a further distance of 50 yards. The victory of the gun was perfect, a single round or two of the 300-pounder shunt Armstrong being sufficient to consign the *Lord Warden* to the bottom. The velocity was not obtained in time.—*The tenth round.*—Anderson gun factory, 12½ tons, 9·22in. gun, 221lb. steel shot; charge, 30lb. This shot passed partially through the hole made in the sixth round, went clear through the structure, filling the deck and back ground with heavy splinters. The velocity was not obtained in time.—*The eleventh round.*—Somerset, 9·22in., 6½ ton gun, 171lb. steel shell, bursting charge, 7lb.; charge, 20lb. Shell struck a previous hole, tearing away another iron knee to the distance of 17 yards in passing through. Timber set on fire, but extinguished by two pails of water. The velocity not obtained in time.—*Twelfth and last round.*—Anderson gun factory, 12½ tons, 9·22in. gun, steel shot of 222lb.; charge, 30lb. Shot passed through the structure, completing the general wreck of the *Lord Warden* target.

STEAM SHIPPING.

Steam Shipbuilding on the Clyde.—Messrs. C. Connell and Co., of Overnewton, have launched the *Macedon*, a screw built for Mr. Little. On her trial trip this steamer ran the measured mile at the rate of 10½ knots per hour. She was engined by Messrs. Caird and Co. The dimensions of the *Macedon* are as follows:—Length, 176ft.; breadth of beam, 23ft.; depth, 13ft. 6in.; the engines are of 52-horse power, and the gross burden of the steamer is 415 tons. Messrs. Henderson, Coulborn, and Co., of Renfrew, have launched the *Egmont*, a screw of the following dimensions:—Length over all, 176ft.; breadth, 25ft.; depth, 12ft. 9in. She is to be fitted with a pair of diagonal oscillating engines of 80-horse power, nominal. Trial trips have been made by the *Little Hattie* paddle, the second of a series of similar vessels, building for a Liverpool firm by Messrs. J. and G. Thomson, of Govan. Messrs. Caird and Co., of Greenock, have launched a paddle named the *Mary*, 220ft. in length, 11ft. breath, and 11ft. depth; she is now being fitted with a pair of oscillating engines of 150-horse power. Messrs. W. Denny and Brothers, of Dumbarton, have launched a screw of 1,014 tons, builders' measurement, for the British Indian Steam Navigation Company. The steamer, which was named the *Punjab*, is the fifth ship of the same size built by Messrs. Denny for the same owners, and a sixth is on the stocks. Messrs. W. Simons and Co. of the London Works, Renfrew, have launched a screw of 800 tons, named the *Madras*, for the same company. The *Madras* is the fourth steamer which Messrs. Simons have built for the company. The *Ella* a paddle, of 886, builders' measurement, built by Messrs. W. Denny and Brothers, and to be supplied with engines of 200-horse power nominal by Messrs. R. Napier and Sons, Lancefield Foundry, Glasgow, has been launched. Messrs. Henderson, Coulhorn, and Co., of Renfrew, have launched a paddle named the *Alekcander*, of the following dimensions:—Length, 160ft.; breadth, 23ft.; depth, 8ft. The steamer is being fitted with a pair of the builders' diagonal oscillating engines, of 60-horse power nominal. A duplicate vessel, to be named the *Michel*, will be launched by the same builders in a few days—both steamers being intended for Russia. Two steamers recently launched by Messrs. A. and J. Inglis, of Pointhouse, for the Queensland Steam Navigation Company, have just made trial trips between the Cloch and Cumbrae lighthouses. The first of these steamers, the *Lady Young*, is a paddle of 648 tons, builders' measurement, and is propelled by oscillating engines of 140-horse power. She is 220ft. long, 25ft. 6in. broad, and 12ft. 6in. deep; and she attained at the trial trip a speed of 13½ miles per hour. The second vessel, the *Platypus*, which is intended for navigating the shallow rivers of North Australia, is a twin screw, of the following dimensions:—Length, 140ft.; breadth, 23ft. 6in.; depth, 11ft.; burthen, 340 tons, builders' measurement. She is propelled by engines of 40-horse power nominal, and attained on her trial trip a speed of 10½ miles per hour, in steaming from the Cloch to the Cumbrae lighthouse, against the tide. The screws of the *Platypus* can be disconnected, and made to work separately, so that the vessel can be turned almost within her own length. The *Platypus* will carry to her destination, in pieces, a saloon paddle steamer, intended to run between Ipswich and Brisbane, Queensland, and of the following dimensions:—Length, 170ft.; breadth, 22ft. 6in.; depth, 6ft. 6in. This vessel will be propelled by a pair of diagonal engines of 90-horse power. Messrs. A. and J. Inglis, of Poenthouse, have launched the *Cawarra*, a paddle of the following dimensions:—Length, 205ft.; breadth, 25ft.; and depth, moulded, 12ft. 6in. She is now receiving her machinery. The *Cawarra* has been built for the Australasian Steam Navigation Company. Messrs. Barclay, Curle, and Co., of Whiteinch, have launched the *St. David*, a screw, of 1,500 tons, built for Messrs. J. and A. Allan, of the Montreal Ocean Steamship Company, and intended to form one of their line between Glasgow and Montreal. The dimensions of the *St. David* are:—Length, 260ft. by 34ft. and 21ft. 9in.; and her engines, which are direct acting and of 150-horse power nominal, are supplied by the builders. A paddle, having three "smoke stalks," has been tried on the Clyde. She was built by Messrs. Randolph, Elder, and Co., of Glasgow, and is intended for the South American trade; she is furnished with three furnaces and three funnels.

TRIAL TRIP OF THE "AVALON."—The trial trip of this steamer, one of those intended by the Great Eastern Railway Company to run with passengers between Harwich and Rotterdam, in connection with the company's trains, took place on the 4th ult. The experimental trip was looked upon as giving the most satisfactory proofs of the merits of the vessel, her speed at the measured mile being 14 knots an hour, the revolutions of the engines being 45 to a pressure of 25 pounds. The *Avalon* is of iron, paddle wheeled, 245ft. over all, beam 27ft. depth 12ft. 8in., and draft 7ft. 6in. She can comfortably carry 250 first-class passengers, with 60 or 70 steerage passengers.

LAUNCHES.

LAUNCH OF A SHIP BUILT ON A NEW CONSTRUCTION.—On the 6th ult., there was launched from Mr. Charles Langley's Commercial Dock, Rotherhithe, an Alabama-rigged patent combination ship, classed A 1 at Lloyd's for fifteen years, belonging to Messrs. Smith, Heming, and Co. She is of 650 tons burden, and is intended for the East India and China trade. She was built from the design and under the superintendence of Messrs. S. H. Harrington and Co., and in consequence of the novel mode of construction has excited much interest. The Admiralty have contracted with Mr. Langley to build an iron clad vessel of war on the same principle. They are about to adopt it in the construction of their new 4,000 tons troop ships, the estimates for which have already been passed. The mode of construction is this:—The frames of the vessel are, in the first place, constructed entirely of angle iron of the same weight as that used in building iron ships of a similar tonnage. Each frame is then riveted to a horizontal keel, stem and stern plate broad enough to fasten the garboard to. A middle line keel plate is then riveted between the upper and lower horizontal keel plates, by means of angle irons running longitudinally the whole length of the ship, forming therewith a strong girder of a similar construction to those used in railway bridges. The half-floor plates are riveted to the middle line keelson between doubling clips of angle iron, and carried up in the usual way to the turn of the bilge, and the reversed frames are riveted on across the floor heads and carried up to the stringer plates. Bull iron beams are then fixed, which makes the whole frame rigid and ready to receive the planking, the first coating of which consists wholly of teak, and is fastened to the frames by galvanised nut and screw-bolt from keel to gunwale. The wood keel is also brought on the iron horizontal keel plate, and fastened to it by means of iron screw-bolts from inside. The garboards are then rabbeted in and fastened through the iron keel-plate with galvanised iron nut and screw bolts. The first skin is 2⅝in. thick and the seams are fitted close, and double fastened to the frames throughout. Diagonal straps of iron ¼in. by ⅜in. are then let in, and on this skin, crossed in squares of about 6ft., fastened through frames when they cross, and carried from keel to gunwale. A suitable composition of chunam is then used, and the outer skin of 2½in. rock elm brought on to the turn of the bilge. Thence upwards 2½in. teak is used. Each plank is fitted to overlap the inner seams (rendering it impossible for the vessel to leak), and then fastened with yellow metal clench bolts to the inner skin, all the holes being carefully bored free of iron frames or straps. By this means the planking of the vessel is tied together vertically as well as longitudinally; no copper bolts or metal sheathing are in contact with iron, and the vessel is felted and sheathed with copper in the ordinary way. The obvious advantage of this system is that there are no through seams, no risk of galvanic action, great longitudinal strength, increased buoyancy, and capacity over vessels built wholly of iron.

RAILWAYS.

HAMMERSMITH AND CITY RAILWAY.—This new line of railway was opened for public traffic on the 13th ult. The line forms a junction with the great Western Railway, commencing at Green-lane, about a mile from the Paddington station, passing by Notting-hill and Shepherd's-bush, terminating at the Broadway at Hammersmith. A short branch, forming a junction with the West London Railway, gives access to Kensington and the districts south of the Thames.

PETROLEUM RAILWAY SIGNALS.—The gas engineer to the London and North Western Railway Company has been directing his attention to the burning of mineral oils for signal purposes, and the lighting of railway stations; and, after a series of experiments, has succeeded in constructing a signal lamp and lantern in which petroleum may be used with perfect safety, and a brilliant and uniform light be obtained. The light is not affected by gusts of wind. It is already in successful operation at several of the stations on the London and North Western Railway. In addition to its employment for railway signals, it may also be used for lighting coal and other mines, lighthouses, and similar places. It is said that whilst the new petroleum lamp gives a large excess of illuminating power, the actual cost, as compared with other oils, is less by upwards of 50 per cent.

RAILWAY ACCIDENTS.

ACCIDENT ON THE SOUTH-WESTERN RAILWAY.—On the evening of the 7th ult. an accident, attended with the loss of five lives, and serious injury to twenty-five others, occurred on the above line. It appears that the train to which the accident occurred, left Ascot soon after 7 o'clock, p.m. and arrived at Egham shortly before 8 o'clock; and during the interval of stoppage, the next train from Ascot came up, just as the first was moving off. The collision was most violent, owing to the immense weight of the following train. It crushed the guard-van to splinters, crushed a second-class carriage next to it, and partly crushed another beyond.

ACCIDENT ON THE MIDLAND RAILWAY.—An accident, by which about thirty persons were injured, occurred on the Midland Railway, at the Lawley-street station, Birmingham, at about half-past nine on the morning of the 10th ult. The space in front of the Lawley-street station is an intricate mass of shunting ground, to which the Derby (Midland), the Worcester and Gloucester, or West Midland, the Grand Junction (going to Aston and Walsall), and the London and North-Western lines converge. All the trains stop at the platform at that station that the tickets of the passengers may be collected there. The railway servants have therefore a very difficult task to perform in seeing that every train of the immense number that pass the station in the course of the day takes its proper course. On this occasion a passenger train was despatched as usual from Derby at seven o'clock. It was due at Lawley-street at twenty minutes after nine o'clock, and it arrived in a few minutes after that hour. At the same time a Derby goods train was making its way over the shunting ground to leave its waggons in the London and North-Western goods station, at Curzon-street. This goods train, instead of being sent in its right direction, was accidently shunted on to the Derby line just as the passenger train came up. The engine of the passenger train struck the tender of the goods trains, but not very violently, as neither of the trains was going at a great speed.

BOILER EXPLOSIONS.

MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.—The ordinary monthly meeting of this association was held May 31st, 1864, when the chief engineer, presented his report, of which the following is an abstract:—"During the last month 226 engines have been examined, and 402 boilers, 16 of the latter being examined specially, and 1 of them tested with hydraulic pressure. Of the boiler examinations, 287 have been external, 18 interual, and 97 thorough.* The following defects have been found in the boilers examined:—Furnaces out of shape, 2 (1 dangerous); fracture, 8 (2 dangerous); blistered plates, 2; internal corrosion, 11; external corrosion, 9 (3 dangerous); internal grooving, 8; external grooving, 4; feed apparatus out of order, 1; water gauges ditto, 9 (1 dangerous); blow-out apparatus ditto, 9; fusible plugs ditto, 2; safety valves ditto, 1; pressure gauges ditto, 11; deficiency of water, 1; total, 78 (7 dangerous). Boilers without glass water gauges, 5; without pressure gauges, 2; without blow-out apparatus, 22; without back pressure valves, 22. I have to report the occurrence of six explosions during the past month, by which 11 persons have been killed, and 13 others injured. None of the boilers were under the inspection of this Association. The following is the tabular statement of explosions from April 23rd, 1864, to May 27th, 1864, inclusive:—

Progressive No. for 1864.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
10	May 5	Locomotive	1	2	3
11	May 9	Locomotive	0	2	2
12	May 13	Plain Cylindrical Egg-ended. Externally fired	1	1	2
13	May 13	Plain Cylindrical Egg-ended. Externally fired	3	3	6
14	May 23	Details not yet ascertained	5	4	9
15	May 26	Double-furnace "Breeches" boiler. Internally-fired	1	1	2
		Total............	11	13	24

No. 10 explosion occurred to the boiler of a locomotive engine, while standing at a short distance from a railway station. The locomotive, which was employed on goods traffic, and had six wheels coupled, was of the ordinary construction, and about ten years old, having been re-tubed two years since. The cylindrical portion of the boiler, as well as the crown of the outer fire-box shell, was rent into a number of pieces; and but little of the portion of the boiler shell between the fire-box and smoke-box left; while many of the tubes were fractured, and the remainder bowed outwards. The fragments were scattered in every direction, and some of them blown to a great distance, one of the spring balances belonging to the safety valves falling through the roof of a cottage, and seriously injuring one of the inmates. The cause of the explosion was attributed at the inquest by three successive witnesses, all of whom were practical boiler makers, to shortness of water and consequent overheating of the plates. This, it was thought, had produced a gas inside the boiler, which, upon ignition from the hot tubes, caused the explosion. A personal examination of the exploded boiler led to a very different conclusion from that given in the preceding evidence. The crown of the inner fire-box, as well as its sides, were found uninjured, and the roofing stays in perfect condition; while the rents, instead of being in the fire-box, which would have been the case had the plates been overheated, were confined to the external shell, as already described; so that it is clear that the explosion was not due to shortness of water. On further examination, it was found that the character of the water was somewhat corrosive, and the surfaces of some of the plates had been eaten into indentations by it; while close to the overlap at a longitudinal seam of rivets, at the left-hand side of the cylindrical portion of the boiler, and in the ring of plates nearest to the smoke-box, a deep furrow was found to have been eaten, which ran longitudinally more than half way across the width of the plate. At this furrow, which was below the water line, the plate had rent, and there can be little question that this rent was the primary one from which the others developed, and to which the explosion had been due. No. 11 explosion. This, like the preceding one, occurred to the boiler of a locomotive engine, while standing very near to the station. The locomotive was employed on passenger traffic, was of the ordinary construction, and about ten years old. The shell rent at the base of the steam dome, which was shot upwards, and thrown to a considerable distance. From this opening a number of rents radiated, and the upper part of the cylindrical portion of the shell was rent into several pieces, which, however, did not fly to any great distance. The consideration of the directions in which the fragments had flown, as well as an examination of the parts themselves, left little room to question that the primary rent had occurred at the base of the steam dome, where the ring of angle iron, with which it was attached to the shell, was found to be severed for a considerable distance through the line of rivet holes. This explosion is considered, therefore, to have been due to the existence of the steam dome, and that, had it not been for this, the explosion would not have occurred.

DOCKS, HARBOURS, BRIDGES, &c.

NEW BRIDGE OVER THE MERSEY.—The Rixton and Warburton Bridge Company are about to erect an iron bridge over the Mersey, about seven miles above Warrington. The bridge will be of one span of 130ft., and approached by 12-yard roads, on the Rixton and Cheshire side of the river. The road will be about 1,000 yards in length, and, on the Lancashire side, about 300 yards. The directors have approved of the plans.

NEW PROMENADE PIER AT LYTHAM.—Operations for the construction of a new promenade pier at Lytham have been commenced. When completed the pier will be in a line with Dieconson-terrace. It will be upwards of 900ft. in length and will extend from the promenade to within a few feet of the low water mark. The pier will be erected on cast-iron piles, and in principle will be somewhat similar to that at Blackpool.

---

* During Whit-week, the ordinary visits of the inspectors were suspended in order that they might be devoted exclusively to the purpose of making thorough examinations, in consequence of which the number just given above has been realised, viz., 115, including internal as well as thorough. Frequently as the attention of the members has already been called to the necessity of making more complete preparation for these examinations, the experience of the past month shows the necessity of doing so afresh upon the present occasion. Many of the boilers have been found at the inspector's arrival at the works to be too hot for entering, and the flues to be choked with soot as well as the plates coated. It must be borne in mind that the inspectors are not sweeps, and that the duty of the inspector only commences when that of the sweep has been completed. The inspector's duty, on making a thorough examination, is not only carefully to investigate the condition of the plates, but also on many occasions to take particulars and dimensions of the flues, stays, &c., which renders it necessary to make notes and sketches, and it will be seen how impossible it is to do this unless the flues are properly swept, and the surfaces of the plates brushed. And although our inspectors, from an anxiety to do their utmost, frequently enter flues which are only fit for a sweep, it is not reasonable to expect them to do this. So that members must excuse its being plainly stated, in order to prevent disappointment, that they must hold themselves entirely responsible if, under such circumstances, thorough examinations are not satisfactory, or, in some cases, not even made at all.

Large Reservoir for Hartlepool.—Arrangement has been made and duly confirmed between the Hartlepool Gas and Water Company and the trustees of the late Duke of Cleveland, for the purchase of about eighty acres of ground on the Hart estate, for the erection of a large soft water reservoir, for the supply of extensive works that are now in course of construction in the outskirts of the town.

The Burnley Waterworks.—Mr. Rawlinson, C.E., has inspected these works. The visit was made to the existing reservoirs and also to the sites of proposed new ones. The inspector reports that the Swindon Old Compensation Reservoir, and the Swindon New Compensation, are neither large nor dangerous in their existing state. The present embankment of Swindon New Compensation is 50ft. high in deepest part, and it was proposed to raise this embankment 20ft. Mr. Rawlinson observes that "the water area is so small and the cost so great, in proportion to the extent of the embankment, that I do not recommend this work to be proceeded with." With regard to the New Compensation Reservoir embankment, which was proposed to be raised 20ft., he observes:—"It cannot, in my opinion, be safely raised as proposed. It may be safely raised up to 10ft., with the extra footing to the embankment now in course of formation." The strange reservoir at Hecknest has a leak in part of the embankment, which is recommended to be upraised as soon as practicable, although there is no absolute danger. It is further remarked that "a new reservoir, to contain not less than 100,000 gallons, may be made safely, immediately above the upper part of Swindon New Compensation Reservoir." The report concludes as follows:—"With professional skill and care, I consider that the proposed works at Burnley, for water storing, may be safely constructed, that the sub-strata are sound, and the material favourable." The reasons urged for the inspection were:—"1. The magnitude of the works, and the immense sacrifice of life and property which might be incurred if the works should be improperly constructed. It would endanger a large portion of the town of Burnley, including the parish church, extensive manufactories, the embankment of the Leeds and Liverpool Canal, and extensive collieries, which would be flooded if the embankment should give way. 2. It was stated that a difference of opinion prevails in the Town Council of Burnley, as set forth in a Burnley newspaper, as to the construction, site, stability, and future superintendence of the proposed reservoir, which causes much anxiety to the owners of property below the reservoir, and to the inhabitants of Burnley. 3. It was stated, on the authority of the town clerk, one of the deputation, that it was the unanimous wish of the Town Council that such an inspection should take place."

MINES, METALLURGY, &c.

Gold from Australian Colonies and New Zealand.—A return has been issued of the quantity and value of gold exported from the Australian colonies, including New Zealand, during the years 1858 to 1862, both inclusive; distinguishing each year what was exported from New Zealand, *via* Victoria or any other of the Australian colonies or ports; and of the quantity and value of gold exported from New Zealand to Great Britain during said years; distinguishing what was exported by the province of Otago and each of the other provinces in New Zealand, either direct to Great Britain, or other colony or port in Australia. The following is the return from New South Wales and Victoria:—1858, £51,999 18*s*.; 1859, £81,504; 1860, £115,290; 1861, £191,234; 1862, £112,949 10*s*. Victoria:—1858, 2,555,263 ozs.; 1859, 2,280,525 oz. 14 dwts.; 1860, 2,128,466 ozs. 11 dwts.; 1861, 1,978,864 ozs. 13 dwts.; 1862, 1,662,448 ozs. 18 dwts.; value, £6,649,624. The returns received from the colony for the years 1858, 1859, 1860, and 1861, do not give the value of the gold. The total exported from New Zealand from the 1st April, 1857, to the 30th September, 1863, is as follows:—Auckland, 5,832 oz., value, £18,601; Nelson, 59,080 ozs., £228,933; Otago, 1,065,851 ozs., £4,130,174; total from New Zealand, 1,130,763 ozs., value, £4,377,708.

Coal in India.—Coal has been found in the Salt Range, near Pind Dadun Khan, in the Punjaub, which has been tested by the chief engineer of the Punjaub and Delhi Railways, and by the locomotive superintendent, and favourably reported upon as well adapted for locomotives. The coal is stated to exist in abundance, and much importance is attached to the discovery. The Punjaub Railway, from Umritsur to Mooltan, 252 miles in length, is expected to be open for traffic by the Viceroy about the end of the current year.

Formation of Iron by Metallurgical Insects.—A Swedish naturalist, M. Sjogreen, has recently published a curious memoir on an iron mineral which is, he contends, the direct work of infusorial animalculæ, living in the midst of sweet water. This ferruginous mineral, known under the name of lake-ore, is sufficiently abundant in Swedish water-courses to be submitted to treatment in ironworks. The memoir of M. Sjogreen was composed with more especial reference to certain specimens of minerals shown in the International Exhibition in London in 1862. A lake in his neighbourhood had fallen much below the ordinary level, and enabled him to follow the evolution of the mineral. The bottom of the lake was in part laid bare, from the extreme lowness of the water, but there still existed depressions, filled by water, and occupied by insects or infusorial metallurgists. These depressions presented a strange and marvellous spectacle. At the bottom of one, which was somewhere about 3ft. in diameter, small creatures of different sizes agitated themselves on the mineral, some being visible to the naked eye, while the others were so small that without a magnifying-glass it would have been impossible to discern them. All were actively engaged in inclosing themselves in a metallic envelope, just as the caterpillar encases itself in a cocoon; and the work seemed to the spectator to be effected in a systematic manner. The iron exists in the waters in a soluble state—or, rather, the waters borrow it from the surrounding lands. Lake mineral is produced with considerable rapidity; in certain lakes from which there had been extracted twenty-six years previously all the metallurgical crop, there was again found after this yield a fresh harvest of almost equal abundance.

Copper, &c.—The usual annual returns show that our imports of copper ore in the year 1863 amounted to 80,693 tons, nearly the quantity in 1862; of regulus, 21,406 tons against 35,388 in 1862, and 20,317 in 1861; part wrought, 7,564 tons, or nearly the same as in 1862; copper manufactures and copper plates engraved, £9,293, which was more than double the amount in 1862, but considerably below that of 1861. The import of the ore is chiefly from South America and Cuba, but Australia sent 6,777 tons last year, British North America, 1,775, and Spain sent 8,635 tons, against only 4,939 in the previous year. The British copper (exclusive of ore) exported from the United Kingdom in 1862 amounted to 43,083 tons, of which 29,674 were in the shape of sheets, nails, &c., a greatly increased export over that of the previous year; there was a large increase in the export to India, and a considerable increase also to France, Russia, Holland, and Turkey. About half this export was from the port of London, and more than a fourth was from Liverpool. Our imports of tin in 1863 were unusually small, only 2,728 tons, with 559 tons of ore and regulus; but the export of British tin, 4,415 tons, was larger than usual—France and the States of America our best customers. Of zinc or spelter we imported the large quantity of 34,572 tons in the past year, receiving it chiefly, as usual, from Prussia and Hamburg, and the export of British zinc reached 5,397 tons, an increase over the previous two years—India our chief customer. Lastly, of lead (pig and sheet) we imported 28,604 tons, a considerable increase over the two previous years; the trade is chiefly from Spanish ports to London and Newcastle. Our exports of British lead comprised pig 26,758 tons, a small decrease from the export of 1862, but a great increase over 1861; and 4,725 tons of rolled and sheet lead, which was an increased quantity. The other exports of lead are in smaller quantities. London is the chief port of departure, and China our chief customer. To the United States we sent only 758 tons of pig, and rolled and sheet lead, in 1861, 32,557 tons in 1862, and only 2,404 tons in 1863. There were exported from the United Kingdom in 1863 7,313 tons of foreign copper and ore, and foreign copper manufactures amounting to £2,956, 1,135 tons of foreign tin, 4,285 tons of foreign zinc, and 689 tons of foreign lead.

Discovery of Coal at Sumatra.—Discoveries of coal of considerable importance have been made at Sumatra. The bearings were first "recognised" in 1858, but they are only now becoming available. These new coal bearings extend over a superfices of more than 10,000,000 square yards, and have an average thickness of nearly 39½in. The cubical content of the coal brought to light will thus be seen to be very great. The bearings form a series of hills from 20 to 25 miles from the chief town of the Bencoulen district, and they are situated in a rough, uneven country, divided by numerous torrents, which render access to it difficult; it may be added that they were on the western spur of the mountain chain which divides the island throughout its length. Some experiments with the Sumatra coal have been made at Cherbourg, by order of His Excellency the Comte Chasseloup-Laubat, and the properties of the new combustible—now utilised by vessels of the Dutch navy which touch at Bencoulen—have been closely scrutinised. The principal bearings are situated near the Kamouning torrent, not far from the small river of Kindanhati. Four explorations made at this point indicated the following result:—First bed, under water, 5ft. thick; second bed, coal and clay alternating, 11ft. 4in. thick; third bed, coal and clay alternating, 5ft. thick; fourth bed, coal and clay alternating, 15ft. 8in. thick.

GAS SUPPLY.

The Rugby Gas Company's directors propose a dividend for the year on shares of the different classes amounting to 15 per cent., and that £200 stock be added to the reserve fund; also that the price of gas be reduced to private consumers from 4*s*. 7*d*. to 4*s*. 2*d*. per 1,000ft., with a discount of 5 per cent. for payment within a month from quarter-day.

The Hinckly Gas Company have resolved that the price of their gas be reduced to the public 10*d*. per 1000; the net price to be 5*s*. 10*d*. instead of 6*s*. 8*d*. as before.

The South Shields Gas Directors have laid the foundation-stone of a new retort-house, which, with other extensive improvements, will be carried out upon the works in Waterloo Vale, in that town. The new works will occupy double the area of the old ones.

The Hawick Gas Company have declared a dividend of 10 per cent. on their paid-up stock, and have resolved that the price of gas be reduced from 6*s*. 5½*d*. to 6*s*. 3*d*. per 1,000 cubic feet.

The East Grinstead Gas Company have declared a dividend of 10 per cent. Although the price of gas was reduced last year from 7*s*. 6*d*. to 6*s*. 3*d*. per 1,000 cubic feet, still the amount from private consumers rose to within £50 of the previous year; and in consequence of the increase of business it has become necessary to enlarge the works.

The Harwich Gas Company have declared a dividend of 6 per cent. for the past year, and the shareholders have determined to increase their capital £2,000, in order to carry out the extension of their works, rendered necessary by the extension of their trade.

The Burslem and Tunstall Gas Company have declared dividends of 10 per cent. on original shares, and 7½ per cent. on new, for the past year, free of income-tax, and have reduced the price of their gas by a scheme of discounts, and speak of a farther reduction in price.

The Town of Machynlleth has been lighted with gas. The price is to be 7*s*. 6*d*. per 1,000 cubic feet.

The Rugby Gas Company's directors propose a dividend for the year on shares of the different classes amounting to 15 per cent., and that £200 stock be added to the reserve fund; also that the price of gas be reduced to private consumers from 4*s*. 7*d*. to 4*s*. 2*d*. per 1,000ft., with a discount of 5 per cent. for payment within a month of quarter-day; that the price for lighting the public lamps after September next be reduced from 58*s*. to 54*s*.; and that the price of gas to the railway companies be reduced from 3*s*. 6*d*. to 3*s*. 3*d*. per 1,000ft.

The Town of Wilna is to be lighted with gas from pine-wood. The basins will contain 60,000 cubic feet of water. The gasometer, of east iron, will be of the same capacity. The plan exhibits three distinct edifices for the distillation of gas, its purification, and distribution. Forty-nine towns in Germany, Hungary, Italy, and Switzerland, and quite lately Helsingfors, owe their lighting to gas distilled from wood or jutesal.

Water and Gas.—The amount of capital sought to be raised in the present Session of Parliament in connection with the water supply and gas lighting of various towns in the United Kingdom was as follows:—Bedford, gas, £21,000; Belfast, water, £350,000; Chelsea, water, £335,000; Cheltenham, water, £116,000; Chiltern Hills, water, £20,000; Clayton, Allerton, and Thornton, gas, £62,500; Deal and Walmer, gas, £16,750; Dover, gas, £49,500; Drogheda, water, £24,000; Exmouth and Budleigh Salterton, water, £10,000; Folkestone, water, £10,000; Furness, gas and water, £50,000; Gosport and Alverstoke, gas, £25,000; Haslingdon and Rawtenstall, water, £33,000; Hertford, gas, £31,000; Huntingdon and Godmanchester, gas, £5,000; the Independent Gas Company, £90,000; Ipswich, gas, £62,500; Kingston-upon-Thames, £81,250; Matlock Bath, water, £5,000; Newcastle-upon-Tyne and Gateshead, gas, £13,500; North Cheshire, water, £47,999; North Kent and Kent, water, £685,000; North Surrey District Gas Company, £125,000; Phœnix Gas Company, £585,000; Pontypridd, water, £8,375; Salisbury, gas, £27,500; South Staffordshire, water, £200,000; Southwark and Vauxhall, water, £300,000; Stirling, water, £7,000; Stockport district, water, £50,000; Stockton and Middlesbrough, water, £198,000; Stroud, gas, £32,000; Tunbridge-wells, gas, £40,000; Ulverston, gas, £13,000; Whitehaven, water, £47,000; Wisbech, water, £24,800; and Wrexham, water, £20,000. Most of these useful projects will doubtless be carried out.

APPLIED CHEMISTRY.

Experiments on Respiration of Plants, &c.—At a meeting of the Munich Academy of Sciences, Baron Liebig presented an interesting paper on certain experiments he had made with an apparatus constructed at the expense of the King of Bavaria for estimating oxygen in various bodies. These experiments prove that not only is oxygen disengaged from the atmosphere by plants, but also, and in considerable quantities, by the decomposition of water in the bodies of carnivorous animals. Baron Liebig is of opinion that this fact will throw new light on the phenomena, still so little understood, of nutrition and digestion.

Nature Printing from Steel.—Mr. Sorby, F.R.S., of Sheffield, describes a new process for printing the texture of "blister" steel. "When iron is converted into steel by cementation, three distinct crystalline compounds are formed, two of which are readily dissolved by diluted nitric acid, whereas one is scarcely at all affected by it. If therefore, a piece of such steel be ground flat and polished, and then placed in the acid, after a suitable amount of action, this constituent retains its original surface and polish whereas the other two are so much dissolved that it stands up in sufficient relief to allow of the blocks being used for surface printing instead of a woodcut, to exhibit the structure of different varieties of steel."

LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT, OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF THE ARTIZAN."

DATED MAY 27th, 1864.

1311 C. Boutet—Automaton brake for the prevention of railway accidents
1312 R. W. Sievier—Improvements in cannons, mortars, or guns
1313 H. M. Harwood & G. Whitford — Bottle holders
1314 D. Clark—Improvements in stench trapped gullies
1315 J. Eastwood—Machinery for puddling iron and steel iron
1316 J. Whitley & D. F. Bower—Manufacture of wheel tyres
1317 G. A. C. Bremme—Apparatus for the puddling of iron and steel
1318 G. T. Bousfield—Improvements in surface condensers
1319 A. Wall—Improvements in purifying oils and converting fatty, vegetable, mineral, or fishy substances into oils
1320 J. H. Burke — Lamps, vessels, tubes, and cocks
1321 W. Hart—Treddle motion arrangements for bottle washing and twisting the wire for wiring the corks of bottles
1322 J. Hudson & C. Catlow—Improvements in looms for weaving
1323 J. B. Fuller—Separating and cleansing vegetable fibres
1324 F. W. Brocksieper—Regulating the flow of gas to burners

DATED MAY 28th, 1864.

1325 J. W. Lees—Cleaning and preventing the formation of deposits upon the heating apparatus employed in boilers for generating steam
1326 J. Dickson—Harrows for cleaning green crops growing on drills or ridges
1327 J. Thomas—Paint
1328 A. Etienne—Construction of carriages and vehicles

DATED MAY 30th, 1864.

1329 M. Curtis—Opening cotton and other fibrous substances
1330 T. Wilson—Improvements in gasaliers or gas slides
1331 H. A. Bonneville—Improvements in the manufacture of swivels
1332 R. L. Hattersley & J. Hill—Improvements in looms for weaving
1333 C. Greenway—Improvements in railway turntables
1334 P. G. Etesse—Preparing cements for making mouldings on wood
1335 T. Drew—Manufacture of paper, papier mache, and millboard
1336 J. Paterson—Improvements in the cooling and preparation of charcoal to be used for refining sugar
1337 W. Halse—Tables
1338 C. Hall—Ploughs and apparatus for working the same and other agricultural implements by steam
1339 J. Huggett—Improvements in steam engines, also applicable to pumps and gas exhausters
1340 W. Smith—Registering the hour at which any desired apartment or spot has been visited
1341 G. Herbert & R. Stainbank—Sounding a bell applied to a buoy or other floating body
1342 W. E. Newton—Treatment of products obtained in the manufacture or refining of sugar

DATED MAY 31st, 1864.

1343 F. Rochette—Hygienic and menstrual drawers
1344 G. Haseltine—Improvements in rifles and other fire arms
1345 P. Derley—Improved machine for testing the strength of wire
1346 G. Davies—Artificial teeth and moulds for forming the same
1347 R. A. Brooman—Reducing the circumference of metal hoops, rings, and tyres
1348 J. George—Fire-escape
1349 J. Young—Treatment or distillation of bituminous substances
1350 J. M. & J. Stanley—Apparatus to be applied for steam and blast engines, pumps, and water mills
1351 J. Fowler & T. Webb—Improvements in steam carriages to travel on common roads and portable steam engines
1352 W. & S. Firth—Cutting coal, stone, and other minerals

DATED JUNE 1st, 1864.

1353 J. Platt & E. Hartley—Improvements in looms for weaving
1354 T. Eckersley — Improvements in apparatus used for winding signals
1355 R. E. Donovan—Improvements in the means for the prevention of fraud
1356 J. Taylor—Improvements in propellers for ships and vessels
1357 G. E. Dering—Fastenings for the permanent way of railways
1358 C. R. Humphrey & J. Hasler—Preparing dough and paste
1359 A. Long—Apparatus to facilitate the acquisition of languages
1360 H. Ambler—Improvements in singeing yarns and fabrics
1361 S. Scrine—Improvements in rope making machinery
1362 F. O. Ward—Manufacture of chromic acid and chromates
1363 L. Kinnings, G. Gibbs, & W. T. Edwards—Crinoline fasteners
1364 J. Sykes — Improvements in apparatus for steucilling
1365 A. V. Newton—Apparatus to be applied to clavicord instruments

DATED JUNE 2nd, 1864.

1366 O. E. Prieger—Manufacture of ferromanganese and cupromanganese
1367 P. A. L. de Fontainemoreau—Cutting leather, stuff, and millboard
1368 W. Cormack—Distillation of all solid matters or semi-solid matters
1369 R. Threlfall & R. W. Pitfield—Spinning cotton, wool, and flax
1370 W. H. Mellor—Self-acting mashing or saturating apparatus
1371 E. Myers—Improvements in the construction of rotary pumps
1372 R. A. Brooman—Improvements in ordnance and gun carriages
1373 R. A. Brooman—Lubricating axles and other moving parts of machinery
1374 W. Clark—Treating animal, vegetable, and mineral matters
1375 F. O. Ward—Improvements in treating alkaliferous minerals
1376 W. E. Newton—Cooling the injection water of marine steam engines
1377 J. J. McComb—Presses for forming bales of cotton
1378 G. Coles, J. A. Jaques & J. A. Fanshawe—Improvements in the manufacture of tubular and hollow articles

DATED JUNE 3rd, 1864.

1379 J. W. Lee—Traction engines for ploughing and thrashing
1380 F. Ashe—Fastening and securing tires upon wheels for carriages
1381 J. B. Heal—Depositing turnip and other seeds and manure
1382 A. H. Williams—Fastening for purses, pocket books, and belts
1383 W. Calvert—Improvements in the construction of ships' propellers
1384 W. E. Newton—Improvements in planing machines
1385 T. Holden—Driving cylinders and doffers of carding engines
1386 W. Clark—Electro-magnetic and magneto-electric apparatus
1387 B. Azulay—Treating petroleum and its products

DATED JUNE 4th, 1864.

1388 W. Houghton, G. Burrows, & C. Oldroyd—Self-acting mules
1389 T. Wilson—Breech-loading fire arms and projectiles and cartridges
1390 F. Tolhausen—Improvements in purifying oils or refining oils
1391 E. Ledger—Dividing into filaments various materials used in the manufacture of paper
1392 J. Smith—Apparatus for weaving ornamental fabrics
1393 W. T. Cheetham—Obtaining hydraulic motive power
1394 G. Coles, J. A. Jaques, & J. A. Fanshawe—Producing thin strips or filaments from various substances
1395 W. J. Matthews—Improvements in breech-loading fire arms
1396 H. Hill—Improvements in the manufacture of taps
1397 G. H. Ellis — Washing, wringing, rinsing, mangling, and drying clothes
1398 J. Sunder—Ordnance
1399 J. Dodge—Cutting the teeth of bevel wheels or patterns for such wheels

DATED JUNE 6th, 1864.

1400 B. E. M. Crook—Boilers for heating buildings and other structures
1401 J. Napier — Separating certain metals and metallic substances from ores and other matters
1402 G. Berrey & J. Litchfield—Carriages employed in bobbin net or twist lace machines
1403 W. E. Gedge — Typographical composing machinery
1404 G. Migotti—Clearing away and removing sand, mud, or other detritus from situations where such removal is desirable
1405 W. H. Preece—Improved domestic telegraphic apparatus
1406 E. Loysel—Obtaining extracts from tea, coffee, and other vegetable substances
1407 T. Aveling & T. Lake—Apparatus to be used in steam cultivation
1408 W. Clark — Preparation of phosphates of ammonia and ammoniaco-magnesian phosphate

DATED JUNE 7th, 1864.

1409 E. J. Hughes—Improvements in dyeing and printing
1410 W. Smith & J. G. Fildes—Improvements in cotton gins
1411 W. Avery—Machine for grinding the tools used in turning the heads of wood screws and other similar articles
1412 H. A. Bonneville—Improvements in telegraphic printing apparatus
1413 W. Clark—Application of apparatus for the printing of fabrics
1414 R. A. Brooman—Feeding wool and other textile and filamentous substances into carding, combing, and other machines
1415 J. Fraser—Arranging and actuating window curtains
1416 J. Beck—Water closets, lavatories, urinals, valves, and stench traps
1417 J. A. Wade—Machinery for treating clay and other substances
1418 A. T. Weld & J. F. Powell—Separation of animal substances from rags of mixed fabrics
1419 A. A. Lnrmuth—Improvements in hats, caps, and bonnets
1420 W. E. Newton — Mounting and operating heavy ordnance

DATED JUNE 8th, 1864.

1421 E. Suckow—Preparing, doubling, or twisting cotton and wool
1422 J. Parkes—Handles for carpet bags, portmanteaus, ladies' reticules, packages, and vessels
1423 A. Bragg & G. W. Bridgeman—Construction of screws
1424 J. H. Johnson—Construction of steam generators
1425 T. Richards—Improvements in liquid manure and water carts
1426 F. H. Warlich — Artificial block fuel and coke
1427 J. T. Crick—Manufacture of boots, shoes, and slippers
1428 A. Tweedale—Improvements in temples for looms
1429 A. V. Newton—Machinery for making horse shoes

DATED JUNE 9th, 1864.

1430 M. & J. Smith—Improvements in machinery for corking bottles
1431 P. M. Parsons—Improvements in ordnance, fire arms, and projectiles
1432 R. Aldridge—Working the rudders of boats, ships, and other vessels
1433 R. Rowat—Apparatus for separating granular matters
1434 J. Onions—Improvements in the manufacture of iron and steel
1435 W. C. Cursan—Welding steel and malleable iron
1436 M. Henry—Improvements in gas regulators, gauges, and clocks
1437 H. W. Hayden — Improvements in breech-loading fire-arms
1438 N. Snrony—Production and treatment of photographic portraits or pictures

DATED JUNE 10th, 1864.

1439 J. Hardacre — Preparing cotton and other fibrous materials to be spun
1440 F. Tolhausen — Improvements in braiding machines
1441 W. Hugo & A. Domeier — Manufacture of umbrellas and parasols
1442 J. P. Williams & T. Robinson—Annealing wire
1443 C. H. Snell—Manufacture of soaps and saponaceous compounds
1444 R. A. Brooman—Frames for spinning wool and cotton
1445 W. H. James—Improvements in steam and air engines
1446 J. Foxley—Bricks for walls to which trees are to be attached
1447 C. W. Siemens — Apparatus for producing combustible gases

DATED JUNE 11th 1864.

1448 R. Hall & J. Chambers—Improvements in looms for weaving
1449 S. Tuchet—Construction of rollers for window blinds
1450 A. Walker—Construction of steam and sailing vessels
1451 W. Abbott—Lantern
1452 P. & J. B. Spence—Calcining and smelting copper ores
1453 G. Rydill—Treating mixed fabric rags containing vegetable and animal fibre

DATED JUNE 13th, 1864.

1454 H. R. de St. Martin—Instruments for describing or drawing elliptical figures
1455 E. G. Fitton — Improvements applicable to carding engines
1456 W. Sharp—Purifying and increasing the illuminating power of gas
1457 J. Grant—Trucks and turntables for portable railways
1458 J. M'Elroy — Improvements in electro-telegraphic apparatus
1459 W. E. Gedge—Improved fagots for lighting fires
1460 W. Martin—Working mangles employed in finishing cloth
1461 R. A. Brooman—Improvements in engine pits for railways
1462 R. Kendrick—Embossing in coloured relief on note paper and envelopes
1463 J. G. Marshall — Improvements in steam engines

DATED JUNE 14th, 1864.

1464 C. Armbruster — Breech-loading and other small fire arms
1465 E. Pope—Improvements in breech-loading fire arms
1466 T. Agnew—Manufacture of picture frames and similar articles
1467 S. Calley—Improvements in the construction of bridges and viaducts
1468 J. Brown, J. T. Way, & T. M. Evans—Sheathing ships
1469 G. A. Burn—Improvements in stoves and fire-places
1470 B. Fothergill—Production of slivers of wool and other fibrous substances
1471 J. Reid & T. Buckley—Improvements in the manufacture of felts
1472 W. Tregay—Improvements in apparatus for boring rocks

DATED JUNE 15th, 1864.

1473 P. B. O'Neill—Sluice and other cocks, valves, and taps
1474 W. E. Newton—Construction of pulley blocks and sheaves
1475 M. A. F. Mennons—Improvements in field artillery
1476 J. H. Brierley—Ornamentation of ladies' fancy leather belts
1477 W. Dawes—Organs, harmoniums, and other musical instruments
1478 C. Taylor & J. Dow—Working the valves of steam and other engines
1479 J. Bennie—Shearing, cutting, punching, or rivetting
1480 F. A. E. G. de Massas—Machinery for treating cotton seeds
1481 G. S. Hooker—Fitting and working spindles and millstones
1482 R. A. Brooman—Tuning pianofortes
1483 A. Ellissen—Cultivating land
1484 J. A. Pols—Obtaining refined oils
1485 J. Fletcher & H. Bower—Feeding boilers
1486 R. Whiteside—Preserving iron ships
1487 G. Gondelfinger & J. L. Bichst—Mechanism of remontoir in pendant
1488 J. Lancelott—Chain bands
1489 W. E. Gedge—Converting into manure the bones of horses, cattle, and sheep

DATED JUNE 16th, 1864.

1490 J. Edwards—Permanent way of railways
1491 S. Truss—Permanent way of railways and tramways
1492 S. Young—Obtaining motive power
1493 R. W. Thomson—Dividing rock and stone
1494 M. A. Muir & J. Mcllwham—Railway chairs and sleepers
1495 J. Day—Sliding gasaliers
1496 T. J. Hughes & W. H. Hotten—Composition for coating and insulating
1497 W. E. Gedge—Steam engines
1498 G. H. Ozouf—Utilisation of carbonic acid
1499 G. Newton & J. Braddock—Gas meter
1500 J. G. Jones—Getting coal and other minerals
1501 J. Macartby—Cooling fluids
1502 W. Clark—Lessening the effects of collisions on railways
1503 W. C. Jay — Ornamenting ladies' wearing apparel
1504 R. & L. R. Bodmer—Artificial stone
1505 G. B. Morris, W. B. Price, & J. L. George—Dressing flour

DATED JUNE 17th, 1864.

1506 P. Spence & H. D. Pochin—Smelting copper
1507 W. Clark—Dyeing fibrous materials
1508 M. E. Brown—India rubber tubes and caps
1509 J. H. Johnson—Cleansing and bleaching wool
1510 T. T. Coughin—Compressing air or gases
1511 J. Hodges — Digging, raising, and treating peat and bog earth
1512 J. J. Bennett—Pile drivers
1513 W. H. Tooth—Generating gases
1514 W. H. Tooth—Iron and steel

DATED JUNE 18th, 1864.

1515 T. Agnew—Covering surfaces with composition
1516 W. Rowland—Crinoline and quilted skirt
1517 E. M. Boxer—Projectiles
1518 W. Whiteley and G. Harling—Self-acting mules, horses, and billeys
1519 J. H. Johnson—Grinding and polishing glass
1520 J. H. Johnson—Looking glasses
1521 T. T. Coughin—Projectiles

DATED JUNE 20th, 1864.

1522 S. G. Hewitt—Sails
1523 R. Jones—Preserving animal and vegetable substances
1524 J. C. Brentnall and R. Kedge—Preparing, spinning, and doubling cotton
1525 R. Smith and C. Sieberg—Obtaining colouring matters
1526 J. Johnson—Stoves and stove grates
1527 A. Smith—Producing frills and gathered work
1528 G. Beard—Needles
1529 J. H. Beattie—Removing and preventing incrustations in steam engine boilers
1530 W. Crozier—Applying gates to docks, locks, and other like structures
1531 T. Worsdell—Pulley or shear block
1532 T. Mayor—Roving frames

DATED JUNE 21st, 1864.

1533 W. A. Ahegg—Distilling liquors
1534 J. Holmes—Beer engines
1535 J. Thompson—Cutting, shaping, and grinding iron and other metals
1536 H. A. Bonneville—Grinding grain
1537 M. Radcliffe—Embossing and finishing woven fabrics
1538 W. J. Pughsley—Obtaining sulphuric acid
1539 E. Rowland—Breaking and scutching flax
1540 C. A. Martin—Dyeing and printing
1541 H. Philips—Glazing of railway hoists
1542 W. Carrington and T. Turner—Churns
1543 T. O. Dixon—Stoppers for bottles
1544 W. E. Gedge—Permanent way of railways
1545 J. Forbes—Sulphate of ammonia
1546 A. Smith—Regulating the speed of sewing machines
1547 T. J. Denne—Card and millboard boxes
1548 J. H. Johnson—Raising water
1549 I. Buckley and E. Crossley—Forging machine
1550 J. Bottomley—Carriages
1551 E. A. Inglefield—Steering ships

DATED JUNE 22nd, 1864.

1552 T. Whitehouse—Furnaces
1553 G. Spencer—Blast pipes and chimneys of steam engines
1554 J. Aldred and P. Bainbridge—Breech-loading guns
1555 W. Smith—Printing machines
1556 C. Heptonstall—Stays
1557 A. Freeman—Lubricating revolving frictional surfaces

ty o
omes
eater
will

ward
f the
ered
in of

ably
than
Mr.
iver-
ngly
ified,
neral
d of
dock

very
l its
s the
r to
any
one
p to

trac-
d the
have

ved,
nade
pre-

ition
ton,
ittee
then
ould
Mr.
ther
the
port
our

1

=

L:

w

13
13
13
13
13
13
13
13
13
13
13
13
13
13
13
13
13
13

THE ARTIZAN.

No. 20.—Vol. 2.—Third Series.

AUGUST 1st, 1864.

HISTORICAL AND DESCRIPTIVE SKETCH OF THE MERSEY DOCKS AND HARBOUR.

(*Illustrated by Plate* 265.)

We have stated in our introductory paper that in 1709 an engineer was sent down from London, at the request of the Corporation, to make plans of a dock. We have, however, been unable to ascertain what were the particular grounds for choosing the site upon which the old dock (filled up in 1826) was built, nor whether that site was recommended to the engineeer (Mr. Thomas Steers) by the Corporation, or whether it was selected by himself after mature consideration. That dock stood upon the present site of the Custom House; and by reference to plates Nos 264 and 265, it will be seen that one of the immediate results of its construction was the reclamation of the tidal creek or pool, from which the town derives in part its name. Of the pool itself no visible traces remain at this period, and where formerly, according to tradition, the mythical Liver was wont to spread its wings, the thriving merchant and the busy tradesman now display their wares with more or less enticement to the numerous traders and seafaring men who frequent the now hospitable banks of the Mersey.

In the course of a Parliamentary inquiry, occasioned some twenty years ago by the proposed construction of docks on the Cheshire side of the river, and to which we shall have occasion to refer at length hereafter, it has been stated in evidence, by an eminent engineer (Mr. Rendell), in reference to the Wallasey pool, that "it is the fate of all such creeks to silt up in process of time;" and the following extract from the letter of Sir Edward Moore, to which we had occasion to refer in our first paper, seems to indicate that the pool disclosed signs of a silting process at the time when that gentleman wrote, *i.e.*, between 1665 and 1670, or at least that strong doubts were entertained as to the possibility of keeping it open without resorting to some artificial means. In the course of this letter, Sir Edward Moore complains of Lord Caryl Molyneux for having caused the deviation of a brook from its original course into the pool, and among other reasons adduced to show why that course should not be altered, he says—

"The second reason that it should run into the pool is, that if ever the pool be cut navigable, of necessity all such cut, where ships are to ride, must have a considerable fresh stream to run continually through it, or it will quickly wreck up; or else there must be convenient places for raising great dams of water to let out with flood gates when necessity requires for cleansing the channel."

Next to the historical interest attaching to this document, as showing indirectly what was the actual condition of that creek, and giving an insight into the speculations indulged in some 200 years ago, respecting the probable manner of accommodating the future trade of the port, and by no means inferior in value, is the technical interest attaching to it as being in all probability one of the oldest documents extant, in which the idea is broached of scouring a navigable channel by means of waters penned up behind flood gates specially prepared for the purpose; and this interest is greatly enhanced when it is remembered that these suggestions were written down, not by a professional man, but by an opulent landowner in the town and its neighbourhood; they are in fact almost identical in substance with the following *dictum*, embodied into a report on embankments in the Mersey, by Mr. Whidbey, in 1818, then Admiralty Engineer at Plymouth :—

"Tidal harbours are deep, or otherwise in proportion to the quantity o water that flows into them from the sea, and the fresh water that comes down from the interior. The greater the quantity of water, the greater will be the depth, from the effect which the increased body of water will have in scouring the bottom at the time of ebb tide."

With sound engineering ideas, like those embodied into Sir Edward Moore's note, innate, as it were, into the minds of the public men of the borough, it is scarcely to be wondered that Liverpool should have steered clear of such great and irretrievable mistakes as have proved the ruin of many harbours.

It so happens that the Mersey is shallow on the Liverpool side, probably as the result of a silting process going on with greater activity here than on the Cheshire shore. This, at any rate, was the opinion of the late Mr. Rendell; and the cause assigned by him for his belief was that the Liverpool shore was the lee shore of the river. His opinion, though strongly combatted by others equally eminent in the profession, is partly verified, however, by the formation of Pluckington Bank, and partly by the general structure of the foreshore, so far reclaimed, which chiefly consisted of marine sand and alluvial deposit, to the entire depth to which the dock works have been carried.

The consequence of this shallowness of water has been, from the very beginning of this great work, to compel the Dock Committee and its engineers to encroach upon the tidal space, from time to time, as the wants of the port demanded further dock accommodation, in order to get the dock entrances as far as possible into deep water. Such at any rate was the primary motive, though at a later period not the only one which has caused the work of abstraction to go on uninterruptedly up to the present period in the lower estuary.

The accompanying wood engraving, p. 170, illustrates the various abstractions which have been made at successive periods for dock purposes, and the areas of the respective spaces embracing the operations of each period have been computed by Mr. Hartley at the following amounts:—

Lancashire Side ...	1st Period,	1650 to 1725 =	36 acres
	2nd ,,	1725 to 1803 =	120 ,,
	3rd ,,	1803 to 1836 =	156 ,,
	4th ,,	1836 to 1843 =	193 ,,
	5th ,,	1843 to 1848 =	258 ,,
Further Proposed Abstraction as per Parliamentary Bills of 1863—64, about...			150 ,,
Cheshire Side, Single Period, 1825 to 1858 ... =			170 ,,
Total			1,083 ,,

The illustration referred to and the above figures, it should be observed, do not take cognizance of the extensive abstractions which have been made in the upper estuary; but of these we shall have occasion to speak presently.

No sooner, however, had engineering been raised to the dignified position of a distinct profession by the works of those great masters, Smeaton, Brindley, Telford, and Rennie, than we find the Dock Committee anxious as to the maintenance, if not the improvement, of the then condition of the harbour, in quest of the best advice they could obtain in furtherance of their objects. Thus we find that in 1808 Mr. Rennie was employed to report as to the best means of obtaining further dock accommodation, and as to the amount which the then trade of the port might require; that in 1818 Mr. Whidbey was employed to report as to the best means to be adopted for the preservation of the harbour

PLAN OF THE MERSEY DOCKS AND HARBOUR.

ABSTRACTIONS MADE AT SUCCESSIVE PERIODS FOR DOCK PURPOSES.

in 1822 also Messrs. Whidbey, Chapman, and Rennie made a report on the same subject; and again, in 1826, Mr. Giles, after having made a survey of the tidal estuary and of its approaches, gave in a similar report.

But of all the workers in, and contributors towards that great object—the preservation and the improvement of the harbour of the Mersey—none have displayed so much zeal, so much diligence, and, we feel inclined to say, so much intelligence, as Admiral Denham, who (then a Lieutenant R.N.) was appointed Local Marine Surveyor in 1833 by the Lords of the Admiralty, and whose labours in this cause have been so manifold and fraught with such beneficial results that by themselves alone they would form one of the most valuable contributions to engineering literature—and here especially deserve to be brought before our readers in their entirety to such extent at any rate as is compatible with the general object which we have in view. It is chiefly owing to Admiral Denham's labours if not by his direct advice, that a demand was made for the establishment of a Board of Conservancy, to which the Board of Trade appears to have willingly acceded; since we find that in 1839—40 they employed Messrs. John and George Wilkin to inquire into the best mode of protecting and preserving the navigation of the river. These gentlemen made a report on that subject, which was laid on the table of the House of Commons on the 14th of August, 1840, and as it contains abstracts of most of the reports already spoken of, we here produce a summary of it, previous to passing in review the labours of Admiral Denham in this direction.

The report commences by stating that the time of Mr. George Wilkin had been occupied with this subject from the beginning of the month of March, 1839, and that at his recommendation, the corporation of Liverpool had employed Mr. Eyes to make an accurate report and survey of the shore within the port of Liverpool. This survey, the report states, contains a description and custom of each township, showing whether the same was a manor or reputed manor, and whether any and what claims were made on the shore, or whether any privileges exercised therein; of the names of the proprietors of land adjoining the beach; of the encroachments made thereon, and on the marshes over which the tide formerly flowed in the upper part of the river. Messrs. Wilkin add, that the area of the estuary of the Mersey from the Black Rock to the mouth of Woolston Weir, above Warrington Bridge, where the tide ceases, is, according to Capt. Denham, 23,062 acres, over which, at a 22ft. tide,* 736,945,213 tons of water flow, and that no less than 13,444 acres of marshes have been abstracted from the tide way, equal to about 25 millions of tons of water calculated for a 22ft. tide.

Messrs. Wilkin then proceed to give summaries of the opinions delivered by engineers previously engaged on the same subject. The first report to which they refer is that made by Mr. Whidbey in 1818. In this report Mr. Whidbey observes that the Mersey is an inlet of the sea rather than a river, being kept open entirely by the quantity of water that flows into it, and not by the trifling stream which it receives at Warrington and Frodsham Bridge; that tidal harbours are deep or otherwise in proportion to the quantity of water that flows into them from the sea, and the fresh water that comes down to them from the interior. The greater quantity of water flowing in, the greater will be the depth from the effect which the increased body of water will have in scouring the bottom at the time of the ebb tide. Mr. Whidbey further states that if all the mud banks above and below Ince and above and below Runcorn, were embanked, leaving a channel only for the waters that come from the interior of the country to discharge themselves, the total ruin of Liverpool would be the consequence; the back water would be so much diminished that the scouring effect would be destroyed, and the sand, driven on towards the entrance of the Mersey by the violence of the north-west and the western gales would in time accumulate beyond the possibility of removal.

The next report referred to is that of Messrs. Whidbey, Chapman, and John Rennie, made in 1822, in which it is stated that numerous jetties have been formed between Runcorn and Fiddler's Ferry for the protection of the land against the violence of the current, extending in many instances much further than is necessary, and for the most part operating as injurious impediments to the tideway which, by obstructing its course, diminish the velocity of the tide and allow time for the alluvial matter with which it is charged to be deposited and form banks and shoals highly injurious to the navigation.

The third report quoted is that of Messrs. Whidbey, Giles, and George Rennie, in 1826, in which they recommend that a quay or other boundary line along the whole of the shores of the River Mersey and its inlets within the influence of the tide, should be accurately defined upon plans confirmed by Parliament. Messrs. Rennie and Giles, after having given particular consideration to the sea channels, and to the river from the black rock to Runcorn, and from thence to Woolston Weir, say, it is admitted by all intelligent and impartial authorities, that the preservation and improvement of the navigable channels of a river depend entirely upon the flux and reflux of the tidal waters, and the discharge of fresh waters, and that these have the most powerful effect during high spring tides and rainy seasons in scouring and deepening such channels through which these waters must flow. The last report quoted is one by Mr. Giles, made in the same year, in which that gentleman gave it as his opinion that by means of a shore and river wall, such a uniformity of flood and ebb current will be established up and down the river, as to produce the best scouring effect of the tide and land waters, and particularly upon the ebb tide, which would be directed more forcibly upon the south-east end of the Liverpool shore than at present, so as not only to prevent a further accumulation of bank, but most probably to lessen the present extent and height of it; and that the further result of forming such uniform lines of shore and river wall would be to equalise and distribute the currents more over the river, above Liverpool in particular, so as to prevent, in a great degree, the accumulation of mud and other sediments under the river walls and at the entrances to the docks generally.

After giving the above summaries, and expressing their general concurrence in them, Messrs. Wilkin proceed to give the opinion of Lieut. Lord, R.N., the then resident Marine Surveyor of the port, on the best mode of preserving and improving the navigation. They say that they had thought it desirable to request the Corporation of Liverpool to state their views as to the plan of operation in the event of a conservancy bill being granted, and that the town clerk had favoured them with two letters from Lieut. Lord to the chairman of the Conservancy Committee, in which he recommends that the line of high water should be accurately marked and defined, and that no future encroachment should be allowed without authority; that the edges of the banks which in the upper part of the river are composed of earthy sand, should be protected by a fencing of stone, or other suitable material to prevent any part from being carried away. This, he says, would render permanent a scouring force of water, which would maintain the sea approaches in an effective state, and it would then remain to watch the changes that might take place on the sandbanks in the river and its approaches, and to adopt such timely remedies as might be deemed necessary. He refers particularly to the dredging operations which were so successfully carried out last year (1839) for a period of ten months, by which means a most valuable channel was opened at a small expense. That success, he says, depends entirely on the column of water running out of the Mersey at ebb tide, and upon a minute attention to what was taking place in that region, he considers the natural formation of the Mersey admirably adapted for scouring and keeping open the sea channels, if encroachments are not allowed to be made on its banks; but he doubts the propriety of scraping and removing rocks.

The recommendation of Messrs. Wilkin to the Board of Trade, founded on the above facts and opinions, was that a public act should be introduced by the Board of Trade for the preservation of the navigation of the Mersey, under the powers of which a Conservancy Board should be formed, the constitution of which, as proposed by them, it is needless here to

* That is a tide which rises 22ft. above the datum of the Old Dock Sill.

explain. It is sufficient for our purposes to state that the Conservancy Act was passed, and we believe we shall be able to show that its operation has been beneficial to the navigation of the river.

The following are the references to the accompanying plate; the several docks, &c., being indicated by numbers; the chief public buildings, railway stations &c., being indicated by letters as under, viz.:—

1. Carriers Dock; 2, Half Tide Dock; 3, Canada Basin; 4, Canada Dock; 5, Huskisson Dock; 6, Huskisson Branch Dock; 7 and 8, Saudon Dock; 9, Sandon Graving Docks; 10, Wellington Dock; 11, Wellington Half Tide Dock; 12, Bramley Moore Dock; 13, Nelson Dock; 14, Salisbury Dock; 15, Collingwood Dock; 16, Stanley Dock; 17, Clarence Graving Docks; 18, Clarence Dock; 19, Clarence Half Tide Dock; 20, Trafalgar Dock; 21, Victoria Dock; 22, Waterloo Dock; 23, Prince's Basin; 24, Prince's Dock; 25, Landing Stage; 26, George's Basin; 27, George's Dock; 28, Landing Stage; 29, Manchester Basin; 30, Canning Dock; 31, Canning Graving Docks; 32, Canning Half Tide Dock; 33, Salthouse Dock; 34, Albert Dock; 35, Wapping Basin; 36, Wapping Dock; 37, King's Dock; 38, Duke's Dock; 39, Queen's Dock; 40, Queen's Half Tide Dock; 41, Brunswick Graving Dock; 42, River Craft Dock; 43, Coburg Dock; 44, Brunswick Dock; 45, Brunswick Half Tide Dock; 46, Brunswick Graving Dock; 47, Toxteth Dock; 48 and 49, Harrington Dock; 50, Egerton Dock; 51, Baths; 52, Tobacco Warehouses; 53, Shipwright's Yard; 54, Dock Yard; 55, Shipwright's Yard; 56, Low Water Basin; 57, Morpeth Dock; 58, Morpeth Basin. A, Lime-street Railway Station; B, St. George's Hall; C, Town Hall; D, Revenue Buildings; E, Sailors' Home; F. Lancashire and Yorkshire Railway Station; G, Canal Basin.

(To be continued.

DIE ENGRAVING, SINKING, AND MULTIPLYING.

By Mr. J. Newton, Royal Mint.

It is more than probable that, with the exception of those who may be practically engaged in the above-named arts, very few persons are acquainted with the modern method of preparing dies, whether for the stamping of coins or the striking of medals. The general belief shared, as we have reason to know, by many scientific men, is, that each individual die used for either of these purposes must first be engraved by the skilful hand of an artist, and that therefore, at her Majesty's Mint, where, in addition to the coins of the realm, all our naval and military medals are struck, a numerous staff of engravers is constantly employed in the preparation of new dies. This is a very reasonable supposition; but as it is also a very erroneous one, it is intended to explain in as popular a way as the subject will admit, the system of die manufacturing as actually carried on at that establishment. It will be found that the processes employed in the conversion of bars of steel as they come from the moulds and mills of Sheffield into coining and metal dies are to the full as interesting as those exercised in any other branch of manufacturing and industrial art.

The ancient plan of getting up dies was undoubtedly identical with that which the public generally believe to be in existence now—namely, that of cutting in the various designs and devices upon softened steel blocks by means of etching tools and gravers, and afterwards hardening, and tempering the engraved blocks by the application of fire and water. By such means it was that the renowned engraver of the times of Oliver Cromwell and the second Charles—Thomas Simon—produced the dies by which the numerous commemoration medals and the coins of those periods were struck. When, however, it became necessary to increase the producing power of the Mint a thousand-fold, as it has been increased of late years, it was essential, also, to devise a mode of producing dies in quantities commensurate with the multiplied demand for money; for dies, though made of steel, are short-lived, and seldom survive one day's use in the stamping press. As usual in this country, mechanical ingenuity kept pace with public requirement, and instead of enlisting into the service of the Mint a small army of engravers, machinery was invented which effectually did their duty. All that was subsequently wanted, therefore, was a master hand to direct and govern the movements of the engraving machines. That master hand, in the form of a chief engraver, has never since been absent, as witness the names of Pistrucci and the Wyons.

It would be unjust to the memory of an individual long since deceased to proceed with our description of die manufacturing without mentioning his name, because the die manufacturer stands chiefly indebted to his skill and perseverance. We refer to Benjamin Huntsman, late of Sheffield, and who invented the best material for dies—cast steel. After many years of patient investigation and experiments innumerable, he succeeded in producing this invaluable metal, and as it will be incumbent upon us to speak of it frequently, it may not be improper to detail very briefly at this point the process of making it. That process has remained unaltered in principle since the days of Huntsman, and is not likely to be deviated from in the future.

The melting of wrought, or bar steel, intended for conversion into cast steel, is effected in small crucibles formed of clay and plumbago, and which are capable of holding about 30lbs. weight each of the metal to be acted upon. Ten or twelve of these are placed in furnaces very similar to those used in ordinary brass founderies. After the crucibles have been brought by the concentrated action of a coke fire to a white heat, they are charged with pieces of bar steel reduced to a particular degree of softness, and weigh about a pound each. When the crucibles are thus loaded, lids of clay are placed over them, the furnaces are filled with coke, and the covers of the furnaces are put down. The intense heat thus generated soon reduces the contents of the crucibles to a liquid state, and induces an ebullition of the metal, resembling somewhat the boiling process in the case of ordinary fluids. When the furnaces require feeding with fresh coke the lids of the crucibles are also removed, and the workmen are enabled to judge as to how far the process is matured. Usually, in about three hours, the molten metal is ready for "teeming." The subsidence of the ebullition, and the dazzling brilliancy of the metal are proofs of the successful completion of the fiery ordeal, and it is then forthwith poured into ingot moulds of the shape and size required. When cold, the resulting ingots are removed, and are in fit condition for the market and the rolling mills or the workshop. Those which are intended for conversion into dies are first elongated into bars, of which we shall have to speak hereafter. Without further preface let us now proceed to deal with the manufacture of cast steel dies as practised at her Majesty's Mint. The whole of those which are used there—and in these days of incessant money-making their name is "legion"—are produced within its own walls. The die department, which occupies what may be termed the left wing of the operative branch of the establishment, is entirely independent of, and distinct from, the coining-rooms. It comprises offices, workshops, stores, a museum (in which are kept specimens of almost every monarch of England, from William the Conqueror to Victoria the Good), and all are conveniently disposed for these purposes. In the workshops are to be found forges, furnaces, lathes, huge presses, annealing and hardening pots of wrought iron, baths for die plunging, and numerous other fitments of a less important, but not less useful kind. The running machinery is driven by a six horse-power steam engine, made by the well-known firm of Boulton and Watt, the present head of which is H. Wollaston Blake, a director, of the Bank of England.

Rectangular bars of the finest cast steel which Sheffield can furnish, and varying in size in accordance with the respective denominations of coin in the British series alone are used in the Mint. There are two substantial reasons for employing highly refined steel in die making. The first is that the elaborate engraving and fine lines of the artist, as placed on an original die, may be satisfactorily copied, and the second that due resistance may be gained by the perfect homogenity and toughness of the metal to the rapidly-repeated and heavy thuds of the coining presses. Constant practice has made the officers and workmen of the department excellent judges of the peculiar mechanical and chemical properties which should distinguish the steel they use. They are consequently not very liable to error in selecting it. It is not essential, perhaps, to explain minutely the peculiarities which distinguish good die steel; but it may be said that that which exhibits, when broken or fractured, a moderately fine grain which is of uniform texture, and when polished is free from spot or blemish is the best. Let it be imagined, for illustration, that a coinage of florins is required to be struck and issued from the Mint, and that the entire duty of engraving, sinking, and multiplying a number of dies for the purpose has to be performed. Then, if we succeed in making the operation understood, our readers will have obtained information as to the manufacture of dies generally, for all pass through similar processes. The engraver will have received his instructions from the master of the Mint. Let us therefore visit his *atelier*, and watch his movements. Having selected with especial care the bar to be first used, tested portions of it with rigorous severity, and thus assured himself of its perfect fitness, the artist will cause it to be sent to the Mint. After one end of the bar is heated to redness in an ordinary forge, two pieces are cut off it of the size required. The resulting blocks are then again heated and swaged into round form. It may be suggested that the bars of cast steel might as well be made round before reaching the hands of the die forgers and that this would save the labour of hammering the blocks into round shape afterwards. The smith's labour, however, is not labour lost, for it gives a density and tensile strength to the embryo dies which they would not otherwise possess, and hence they are eventually found more durable. It will be well to explain, too, that the blocks are not rounded

longitudinally with the bar from which they are cut, but transversely; that is to say, the sides of the bar, form the tops and bottoms of the dies. The grain of the steel is thus made to pass across the dies, and not vertically through them. They are thus rendered less liable to splitting while under the press.

The two rounded blocks are next annealed to the fullest extent possible, and this is done by placing them in a wrought iron pot, covering them with animal charcoal and depositing the whole for twenty-four hours in an oven heated by coke; they are afterwards withdrawn, removed from the pot, and allowed to cool gradually. Next they are taken to the lathe and one end of each is turned. That which is intended to become the "matrix" die (of which more anon) is made perfectly flat and smooth, and it is upon this prepared surface that the artists' talent will have to be first expended. The second block, turned slightly conical, and which is destined to become the "puncheon" may be put out of view *pro tem.* The engraver addresses himself to the work of etching in upon the matrix block his approved design, say of the obverse for the florin. Assured of having put in his outlines correctly, the work of engraving fairly commences, and only those who have witnessed the operation of die cutting can realise the amount of patience and skill necessary for its successful completion. After many weeks of close and constant application the design in intaglio will probably be finished, repeated impressions in clay and soft metal being taken *ad interim* by the artist as tests of the accuracy of his work. Innumerable touchings and re-touchings, with the graver, are indispensable to the minute realisation of the design, but it at last satisfactorily appears on the surface of the softened steel. The letters to form the legend and the date are stamped in by aid of punches, and the matrix, or first die, is engraven. A very important, and to the engraver, an anxious operation follows. It is that of hardening the matrix. In its present annealed condition it is practically useless, and, therefore, the risk must be run of exposing a very beautiful work of art in quick succession to the tender mercies of the antagonistic elements fire and water. There is no escaping this, however; and the artist, if a nervous man, may tremble for the result. His only hope lies in the excessive care with which the work is done, and the excellence of the cast steel of which the die is composed. The preservation unmarred of the delicate lines and tracery which have cost him so many hours and so much exertion is naturally a great consideration. To ensure this, as far as possible, the engraved face of the die is covered by a mask composed of some fixed oil, thickened to the consistency of a paste by the addition of animal charcoal finely powdered. This Ethiopian-like compound is spread over the surface of the engraving to which it closely adheres, filling all interstices.

As an extra precaution an iron ring is usually made to encompass tightly the matrix before hardening, so as to lessen the risk of fracture. In this condition it is deposited with its face downwards in a pot or crucible and buried once more in animal charcoal, *i.e.*, burnt leather, horn, &c. The crucible and its precious contents are placed now in a furnace, the whole being heated to redness. After submission to this saturation of fire, if the term be admissible, for about an hour the pot is withdrawn and the matrix, taken out of it by means of a pair of tongs is instantly and *sans ceremonie* plunged into a cold water bath. The bath is sufficiently capacious to contain as much water as will prevent the latter becoming sensibly warm by the immersion of the red hot die. Held firmly by the workman's tongs, the matrix is swayed to and fro rapidly in the water until it ceases to splutter and hiss at its rough treatment. Should no unusual or singing sound proceed from it while in the bath, the probability is that the expansion induced by the fire and the sudden contraction caused by the cold water have not injured the die, and the engraver may take heart again, for his work is safe and sound. If, on the contrary, it sings the die will be found to have cracked in the process of hardening and his work will have to be done over again. For the reasons previously given such a disastrous result seldom happens at the Royal Mint.

Allowing that all has proved favourable, the coating which protects the engraved surface is removed, and the matrix is forwarded to the polisher, who by pressing its "table," or face, carefully against a flat disc of iron running rapidly in a lathe, and upon which a film of flower emery and oil has been spread, soon produces a mirror-like polish. Tempering is the next operation, for at present the steel is much too hard for its purpose, and this is effected by putting the matrix into water to be gradually heated to the boiling point or by placing it on a red hot plate of iron. In either case the work is done when the die, after a series of chameleon-like changes of colour, assumes that of pale straw. At this juncture, therefore, it is again plunged into cold water, and the obverse matrix is ready for use. Arrangements of a precisely similar character throughout are observedin the production of the reverse matrix, and thus the first and more important stage in the manufacture of coining dies is passed.

It is time that we turned to the second block of steel, namely, that intended for the "puncheon." This has been annealed and turned, not flat, but flatty conical, on the surface to be decorated. Both it and the matrix are thus made ready for a massive and powerful stamping press, with a coarse triple threaded screw of some 6in. in diameter passed vertically through its centre attached to the upper part of the screw, and above the press are two heavily weighted fly arms which constantly tend to force down the screw. To the lower end of the screw, and with its face downwards, the matrix is firmly fixed by a workman, who stands in the recess sunk in the floor to the depth convenient for bringing his eyes and his hands to a level with the bed of the press. The puncheon block is deposited next it with its face turned upwards on the solid cast iron bed of the press, and immediately and fairly below the matrix. All being ready, several strong-armed workmen seize the fly-arms and walking round with them raise the screw and matrix until the latter is several inches above the puncheon block. On a sudden they release their hold and the weighted arms revolving with a speed and force which would be fatal to any person standing in their way, drive down the matrix until it impinges with a dull, heavy thud upon the puncheon block. Again the workmen stand to their (fly) arms and raise the screw of the press. The effect of the blow is then seen in the depressed apex of the cone-topped die which received its impact, and in the transference to itself thereby of a partial copy in relief of the intaglio engraved matrix. The compression of the particles of steel composing the puncheon by the stress of the blow mechanically hardens the puncheon, and before its impression can be completed by a repetition of the act, it must be again annealed. This is effected in the same way as before, the puncheon is returned to the press, and the matrix, now detached from the screw, is placed loosely on the top of it, though, for an obvious reason, in such a way as that the engraving on the matrix and the partly finished impression on the puncheon shall exactly match or fit each other. A blank block of steel is then affixed firmly by aid of set screws to the place before tenanted by the matrix, and may be said to represent a hammer, for it will presently descend with great force upon the matrix. The fly arms are turned backward by the workmen, the press screw is raised, the arms released, and, gathering momentum as they revolve, the hammer block is made to fall heavily on the matrix. The effect of this second blow will, perhaps, be to make the transfer of the engraving as complete on the puncheon as is that of a seal pressed by the hand upon molten sealing wax, or it may be, if the steel is very obstinate, that another annealing and another blow may be required to effect that object eventually, at least the puncheon will be found upon examination to have imbibed an exact and faithful copy in relief of the engravers work on the matrix to the finest line and most minute point of detail. The duty of this latter is now done, at all events for the present, and it is placed in the engraver's closet. Far otherwise is it with the puncheon, for its mission is about to commence. It is therefore hardened and tempered; polished it cannot be, on account of its raised surface, and then returned to the press. Such are the processes pursued in the making of matrices and puncheons in reference both to coining and medal-striking for obverse and reverse, although, from the bold impressions usual on medals, many more annealings and strikings of the puncheons are necessary than of those used for coin. Confining our attention for the sake of brevity to the florin, let it now be presumed that puncheons for its obverse and reverse have been successfully prepared, it remains to be shown how they are put into useful requisition, and how they are made the parents of rapidly-multiplying families of coining dies. Florin bars of cast steel are about 10ft. long, $1\frac{3}{8}$in. broad, and $1\frac{1}{4}$in. thickness; upon these the Mint blacksmith is the first operator. One at a time they are conveyed to the forge, and cut, while hot, into short pieces of $1\frac{3}{8}$in. in length, and in this form, therefore, resemble Fig. 1. These square or

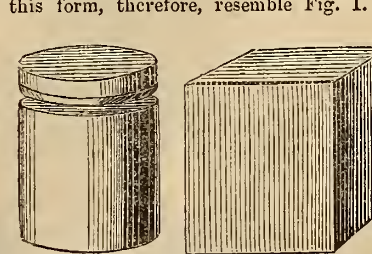


Fig. 2. Fig. 1.

rectangular blocks he next proceeds to hammer into a cylindrical form, as shown in Fig. 2. He then cuts off in a slanting direction one end of each of the die blocks, and shapes them, by way of preparation for the lathe, and thus they take the appearance depicted in Fig. 3. Thus he proceeds with die block after die block until he has accumulated a large quantity and diminished materially the length of the bar off which they have been cut. Owing to the severe hammering to which they have been subjected, they are at this stage very hard, and it becomes necessary to anneal them. This is effected by burying them in iron pots containing animal charcoal, and submitting the whole for many hours to the heat of coke furnaces. Subsequently, the blocks are allowed to cool gradually

among the ashes and cinders of the furnaces, and are then ready for the turning-room and the lathe; here they are topped, as it is termed—that is to say the conical end of each is turned bright and prepared for its impression. After this operation they assume the appearance indicated by Fig. 4, and are removed to the die multiplying press, which is similar in form and arrangement to that already described. The pressman now

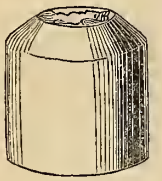


Fig. 5.

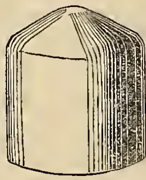


Fig. 4.

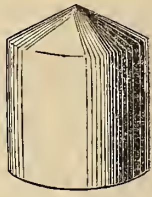


Fig. 3.

steps into his hole, and is surrounded by perhaps a hundred topped die blocks. He affixes now the puncheon in the press, and attendants await his signals to raise the fly-arms, and release them as before described. One by one the blocks are placed so as to receive the impact of the puncheon until the whole have received a partial impression, and present the appearance sketched in Fig. 5. Occasionally, faulty steel is discovered at this stage, and then the defective blocks showing, perhaps, fissures down their sides, are at once cast away to the scrap-heap. Those which exhibit no such symptoms of weakness are returned for another annealing, and will not be again put under the press until the following day. Of course at the Mint dies are continually being manufactured, and each succeeding die sees fresh crops advancing step by step towards completion. We will imagine, therefore, that a moment after the departure of the batch just referred to, to the annealing ovens, another detachment, which were on the day before partly struck, is returned to the die press-room. Then the puncheon, removed and placed successively on the half struck dies, has administered to it in succession the heavy blows of the press, care being taken first to put in the engraving properly, and thus to prevent the marring of the transfer. At this point the puncheon and embryo die are correctly exhibited by Fig. 6. When separated, the latter

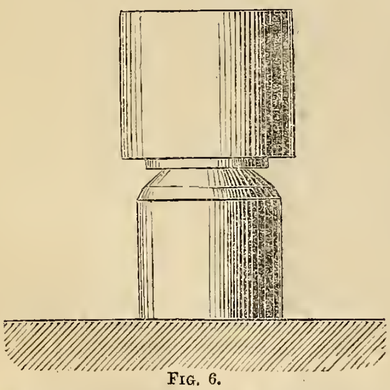


Fig. 6.

assumes the appearance shown in Fig. 7. Possibly, a third annealing and a third striking may be required; but this, of course, depends on the stubbornness or the plasticity of the steel, and with regard to medal multiplying that demands infinitely more labour. Fig. 8 will convey a clear idea of the florin die when its impression is fully developed.

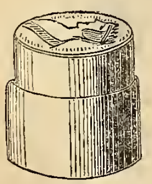


Fig. 9.

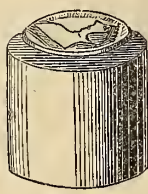


Fig. 8.

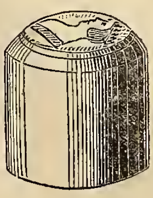


Fig. 7.

We may now be considered to have reproduced, as it were 100 matrices by sheer mechanical and unartistic agencies, for the partially formed dies are really fac-similies of the engraver's handy work, and it will be understood that thousands and tens of thousands of dies may be and are pressed into existence at the Mint in the same way. The power indeed of multiplying copies in this manner is unlimited, for if the puncheon fails either by cracking or sinking, there is the matrix to refer to for the creation of another, while if the matrix itself should break down one of the impressed dies may be used as a substitute for that, and thus, therefore, if the matrix and the puncheon be once successfully completed, whether for coins or medals, a power of reproduction exists in both which obviates all risk of requiring the engraver's aid to renew them. The wholly-struck twin dies are once more annealed and transferred to the turning-room and the lathes. Each one is put into a peculiarly formed chuck fitted with adjusting screws, and so fastened as that the impression is made to run truly. Then all superfluous metal is cut away by sharp tools used by expert workmen, and are thus brought to guaged diameters. They then present the form indicated by Fig. 9. Afterwards come the hardening, polishing, and tempering processes as previously explained, and the whole batch is now ready for the coining press room, there to be used in the multiplication of coins.

The diagrams given have not been drawn to an exact scale, as they are not intended to serve as working drawings but simply as illustrations to make more clear our letter-press description. They are purposely reduced far below the full size of the dies they represent for the purpose of economising space. Figures 10 and 11 exhibit the obverse and reverse

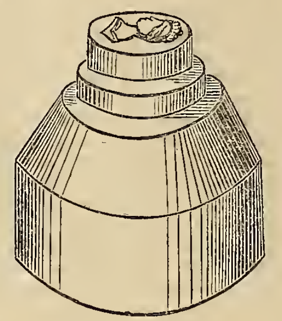


Fig. 11.

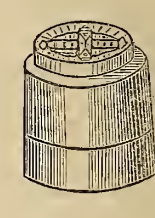


Fig. 10.

florin dies as they appear when mounted and prepared for the coining press. It will be observed that they differ as respects their form, one having a long, and the other a short "neck." The reason for this difference is that when placed in the press the obverse die will have a steel collar (*vide* Fig. 12) fitting over it for the purpose of milling the edges of the

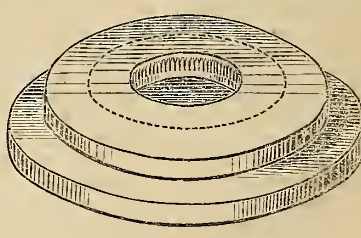


Fig. 12.

planchets of silver at the moment that the impressions on their surfaces are given. This collar, after forming a mould for that purpose, is forcibly depressed by the action of the machinery, and must have room to slide down the neck of the die, and thus to release the imprisoned piece of money when the next planchet is advanced by the feeding apparatus to be stamped. The collar is made to rise again by means of a spring, and in fact it is alternately raised and depressed at the rate of sixty times per minute so long as the press is in motion. The feeding apparatus in advancing displaces the finished coins and leaves planchets in their places. The short necked reverse die simply enters the collars from above, and the force with which it does so gives the images, superscriptions to each piece of softened silver, and expands it into the milled collar or edge mould. Having done this it rebounds upwards to the distance of 'an inch and is free for another descent upon the next planchet. It may be said that there are eight stamping presses at the Mint, and that their united daily production is 200,000 coins, whether of gold, silver, or bronze.

Heat and Light.—If a body, such as a piece of iron, be heated and allowed to cool in the open air, the heat gradually passes off from the surface in straight lines, in the form of rays, in the same manner as light proceeds from the candle or the sun; this is called radiant heat. Radiant heat is supposed to move with the same velocity as light; that is, at the rate of 192,000 miles per second.

DOUBLE CYLINDER EXPANSION STEAM ENGINES.

In THE ARTIZAN of March last we referred to the performance of the *Chile* on her first voyage to Valparaiso, and gave some particulars as to the dimensions of the vessel and her engines. We have since received the accompanying copy of her log and summary of her first voyage.

COPY LOG OF THE PACIFIC STEAM NAVIGATION COMPANY'S STEAMSHIP (PADDLE) "CHILE," FROM LIVERPOOL TO VALPARAISO.

Charles H. Sivell, Commander.—Commenced November 11th, and ended December 17th, 1863.

Date.	Wind.	Course.	Distance run.	Latitude.	Longitude.	Coals Consumed.	Coals Remaining.	Pressure of Steam.	Revolutions per Minute.	Revolutions per Day.	Thermometer in Stoke-hole.	REMARKS.
			Miles.	Deg. Min.	Deg. Min.	Tons.	Tons.	Lbs.			Deg.	
Nov. 11...	N.W.	...	...	...	...	...	584	...	...	1,150	...	Left Prince's Pier at 1.15 p.m. 3 p.m. left N.W. Light-Ship.
„ 12...	N.W.	Various.	254	50 27 N.	6 25 W.	35	549	29	19	25,730	95	Strong breeze, clear weather. Fore and aft sail set.
„ 13...	N.	S. 23 deg. 6 W.	268	46 19 N.	9 5 W.	30	519	30	$19\frac{3}{4}$	28,505	107	Light breeze, and cloudy. Sun obscure.
„ 14...	E.	S. 24 „ W.	288	41 52 N.	11 52 W.	30	489	31	$20\frac{1}{4}$	29,255	104	Light breeze, and cloudy. Sun obscure.
„ 15...	Northerly	S. 23 „ W.	291	37 22 N.	14 26 W.	31	458	31	$20\frac{3}{4}$	30,010	114	Light breeze, and cloudy. Sun obscure.
„ 16	N.E.	S. 21 „ W.	293	32 50 N.	16 38 W.	31	427	$31\frac{1}{2}$	21	30,350	129	Light and variable airs. Sun obscure.
	...	...	36	...	...	4	423	$31\frac{1}{2}$	21	3,714	129	3 p.m. arrived in Funchal roads, and anchored.
	...	...	...	...	...	...	423	...	...	...	...	16th.—8 p.m. left Madeira.
„ 17...	S.S.E.	S. 24 „ W.	198	29 45 N.	18 41 W.	25	398	31	21	20,186	130	Light air, and fine. Fore and aft sail set.
„ 18...	Calm.	S. 24 „ W.	295	25 18 N.	21 04 W.	31	367	$31\frac{1}{2}$	21	30,340	121	Calm, and fine. Fore and aft sail set.
„ 19...	Calm.	S. 26 „ W.	303	20 48 N.	23 30 W.	32	335	32	21·4	37,750	116	Light airs, and fine.
„ 20...	Calm.	S. 24 „ W.	250	...	...	29	306	32	21·5	26,540	121	8 a.m. arrived at St. Vincent, and commenced coaling.
„ 21...	...	...	...	...	...	...	651	...	...	...	...	4 p.m. left St. Vincent; 7.45, stopped 1 hour, the boatswain having fallen overboard.
„ 22...	Easterly.	S. 19 „ W.	200	13 28 N.	26 00 W.	28	623	$26\frac{1}{2}$	$19\frac{1}{4}$	21,960	131	Light easterly, and fine.
„ 23...	Easterly.	S. 20 „ W.	276	9 5 N.	27 26 W.	31	592	$26\frac{1}{2}$	$19\frac{1}{2}$	28,190	140	Moderate, south easterly, and fine.
„ 24...	N.E.	S. 18 „ W.	254	4 54 N.	28 26 W.	31	561	$26\frac{1}{2}$	$19\frac{1}{4}$	27,670	133	Light variable airs, and cloudy, with rain.
„ 25...	Calm.	S. $22\frac{1}{2}$ „ W.	274	0 41 N.	30 11 W.	32	529	$26\frac{1}{2}$	$19\frac{3}{4}$	28,330	120	Light variable airs, and cloudy, with rain.
„ 26...	S.S.E.	S. 24 „ W.	277	3 32 S.	32 4 W.	32	497	$26\frac{3}{4}$	20	28,880	134	Fresh S.S.E. trade, and fine.
„ 27...	S.S.E.	S. 22 „ W.	293	8 04 S.	33 56 W.	31	466	$26\frac{1}{2}$	$20\frac{1}{2}$	29,540	140	Moderate trade, and fine.
„ 28...	S.S.E.	S. 20 „ W.	291	12 39 S.	35 42 W.	32	434	$26\frac{1}{2}$	21	30,326	130	Light variable airs, and overcast. Stopped 1 hour to adjust brasses.
„ 29...	E.	S. 21 „ W.	282	17 02 S.	37 27 W.	31	403	$26\frac{1}{2}$	$20\frac{1}{8}$	28,934	134	Moderate E.N.E., and fine.
„ 30...	E.	S. 24 „ W.	307	21 50 S.	39 47 W.	32	371	$26\frac{3}{4}$	$21\frac{1}{2}$	31,140	136	Fresh N.E. and fine. Strong S.W. and fine.
Dec. 1...	N.E.	S. 37 „ W.	310	25 56 S.	43 11 W.	31	340	$26\frac{3}{4}$	$21\frac{1}{4}$	30,120	125	Moderate S.W. and fine.
„ 2...	S.W.	S. 42 „ W.	289	29 29 S.	46 54 W.	31	309	$26\frac{1}{2}$	21	30,480	120	Light southerly, and fine.
„ 3...	W.S.W.	S. 47 „ W.	293	32 49 S.	51 3 W.	32	277	$26\frac{3}{4}$	$21\frac{3}{4}$	31,490	120	Strong N.W. and cloudy.
„ 4...	N.W.	Various.	300	35 21 S.	55 57 W.	35	242	$26\frac{1}{2}$	$22\frac{1}{4}$	32,260	120	Strong N.W. and cloudy.
„ 5...	...	...	40	...	...	12	230	$26\frac{1}{2}$	$22\frac{1}{4}$	7,114	120	Arrived at Monte Video, and anchored in 4 fathoms.
„ 6...	...	...	...	...	...	15	423	...	...	...	...	3 p.m. left Monte Video. Moderate S.W. gale.
„ 7...	S.W.	Various.	170	37 35 S.	56 34 W.	33	390	21	16	20,586	95	Moderate S.W. breeze.
„ 8...	N.W.	S. 28 „ W.	262	41 30 S.	59 03 W.	33	357	28	$19\frac{1}{2}$	28,080	110	Strong N.W. breeze, and fine.
„ 9	N.W. S.W.	S. 31 „ W.	290	45 39 S.	62 31 W.	33	324	30	20	29,470	103	South-westerly breeze, and cloudy.
„ 10...	W.—S.S.E.	S. 29 „ W.	288	49 51 S.	66 01 W.	31	293	$30\frac{1}{2}$	21·4	30,850	100	Light variable breeze, and fine.
„ 11...	N.W.	Various.	300	Steering Straits of	through Magellan.	29	264	$30\frac{3}{4}$	22	30,840	101	Light airs, and cloudy. 1 p.m. anchored off Chilian Settlement. 5 p.m. weighed, and set-on, heavy S.W. gale. 8 p.m. anchored off Port Famine, and set-on again.
„ 12...	S.W.	Do.	141			21	243	29	20·5	18,850	74	Strong W. gale. 2.20 to 5.30 hove to, off Cape Forward. 8.15 p.m. cleared Straits. Strong N.W. gale, and very heavy sea.
„ 13...	W.	Do.	198	50 57 S.	76 10 W.	23	220	28	18	26,460	110	Moderate N.W. gale. Light airs and hazy; heavy sea on.
„ 14	W.N.W. W.S.W.	N. 3 „ W.	256	46 41 S.	76 39 W.	29	191	25	19	28,620	113	Moderate S.W. gale, and heavy sea.
„ 15...	N.W.	N. 11 „ W.	277	42 12 S.	75 0 W.	30	161	30	20·5	29,660	110	Moderate N.W. gale. Heavy sea.
„ 16...	...	N. 7 „ W.	250	38 0 S.	74 20 W.	31	130	$28\frac{3}{4}$	20·6	29,660	110	Light winds, and cloudy. Decreasing sea.
„ 17	...	N. 21 „ W.	316	33 16 S.	71 50 W.	32	98	32	22·5	32,640	122	Fine weather.
	...	...	19	...	...	3	95	32	22·5	2,900	122	2 p.m. arrived at Valparaiso.

Summary of "Chile's" Voyage from Liverpool to Valparaiso.

Left Liverpool 3 p.m. 11th November, 1863; arrived at Valparaiso 2 p.m. 17th December, 1863.

Stoppages.

	Days.	Hours.
At Madeira	0	5
At St. Vincent	1	8
At Sea, 21st November	0	1
At Sea, 28th November	0	7
At Monte Video	1	22
In the Straits	0	12
Off the Straits	0	1
	4	8

Consumption of Fuel.

	Tons.
Liverpool to Madeira	161
Madeira to St. Vincent	117
St. Vincent to Monte Video	421
Monte Video to Valparaiso	343
	1,042
Consumed in Galleys	20
Total	1,022

	Days.	Hours.
Number of Days on the Passage	35	23
Number of Days under Steam	31	15

Averages.

Speed per hour	12 knots.
Consumption per hour	26·75 cwt.
Strokes per minute	20·76
Pressure of steam	31·6 lbs.

Dimensions, &c., of Paddle Steamer "Chile."

Length	265ft.
Breadth	36ft.
Depth	24ft.
Engines (Randolph, Elder, and Co.'s Double Cylinder Expansion)	300 H.P. nominal.
Displacement on Voyage	2,000 tons.
Midship section—Area	440 tons.
Draught amidships on leaving Liverpool	14ft.
Dead weight on board on leaving Liverpool	600 tons.

ROYAL INSTITUTION OF GREAT BRITAIN.

ON A MAGNETIC EXPERIMENT.

By John Tyndall, Esq., F.R.S., M.R.I.

There are two words which are very often employed in scientific writings—matter and force. The definition of each involves the conception of the other. We know nothing of force save through its operations upon matter, and we know nothing of matter save through the manifestations of its force. The characteristics of any force must be sought in the material changes which it is competent to produce. Some years ago I felt a great interest in the subject of magnetism, and in those years I devised an apparatus to enable me to investigate certain mechanical effects which accompany the act of magnetisation. I wished to apply this apparatus to diamagnetic bodies as well as paramagnetic ones—to bodies such as bismuth, as well as to bodies such as iron. I intend this evening to show you the action of this instrument, and to give, if I can, some explanation of the experiments of others which have been confirmed by my own.

Let us pass quickly in review the excitation of this wonderful power of magnetism. Here is a strong horseshoe magnet set upright, and here is a bent bar of steel, whose arms are the same distance apart as those of the horseshoe magnet. I draw the bent steel bar over the ends, or the poles, as they are called, of the magnet. It suddenly obtains the power of attracting this iron keeper and holding it fast. I reverse the stroke of the steel bar: its virtue has now disappeared; it is no longer competent to attract the keeper. I continue the stroke of the steel bar in the last direction, and now it is again competent to attract the iron; thus I can at will magnetise and demagnetise this bent piece of steel.

Here is a fine permanent magnet constructed by Logeman of Haarlem, and competent to carry a great weight. Here, for example, is a dish of iron nails which it is able to empty. At the other side of the table you observe another mass of metal, bent like the Logeman magnet, but not, like it, naked. This mass, moreover, is not steel, but iron, and it is surrounded by coils of copper wire. It is intended to illustrate the excitement of magnetism by electricity. At the present moment this huge bent bar is so inert as to be incapable of carrying a single grain of iron. I now send an electric current through the coils that surround it, and its power far transcends that of the steel magnet on the other side. It can carry fifty times the weight. It holds a 56lb. weight attached to each of its poles, and it empties this large tray of iron nails when they are brought sufficiently near it. I interrupt the current: the power vanishes, and the nails fall.

Now the magnetised iron cannot be in all respects the same as the unmagnetised iron. Some change must take place among the molecules of the iron bar at the moment of magnetisation. And one curious action which accompanies the act of magnetisation I will now try to make sensible to you. The effect I wish to make manifest was discovered by Mr. Joule,* and was subseqeutly examined by MM. De la Rive, Wertheim, Marian, Matteucci, and Wartmann. It is this. At the moment when the current passes through the coil surrounding the electro-magnet, a clink is heard emanating from the body of the iron, and at the moment the current ceases a clink is also heard. In fact, the acts of magnetisation and demagnetisation so stir the atoms of the magnetised body that they, in their turn, can stir the air and send sonorous impulses to our auditory nerves.

I have said that the sounds occur at the moment of magnetisation, and at the moment when magnetisation ceases; hence, if I can devise a means of making and breaking in quick succession the circuit through which the current flows, I can obtain an equally quick succession of sounds. I do this by means of a contact-breaker which belongs to a Ruhmkorff's induction coil. Here is a monochord, and a thin bar of iron stretches from one of its bridges to the other. This bar is placed in a glass tube, which is surrounded by copper wire. I place the contact breaker in a distant room, so that you cannot hear its noise. The current is now active, and every individual in this large assembly hears something between a dry cackle and a musical sound issuing from the bar in conseqence of its successive magnetisation and demagnetisation.

Hitherto we have occupied ourselves with the iron which has been acted upon by the current. Let us now devote a moment's time to the examination of the current itself. Here is a naked copper wire which is quite inert, possessing no power to attract these iron filings. I send a voltaic current through it; it immediately grapples with the filings, and holds them round in a thick envelope. I interrupt the current, and the filings fall. Here is a compact coil of copper wire which is overspun with cotton to prevent contact between the convolutions. At present the cotton is inert; but now I send a current through it: a power of attraction is instantly developed, and you see that it is competent to empty this plate of iron nails.

Thus we have magnetic action exhibited by a body which does not contain a particle of the so-called magnetic metals. The copper wire is made magnetic by the electric current. Indeed, by means of a copper wire through which a current flows we may obtain all the effects of magnetism. I have here a long coil, so suspended as to be capable of free motion in a horizontal direction: it can move all round in a circle like an ordinary magnetic needle. At its ends I have placed two spirals of platinum wire which the current will raise to brilliant incandescence. They are glowing now, and the suspended coil behaves in all respects like a magnetic needle. Its two ends show opposite polarities: it can be attracted and repelled by a magnet, or by a current flowing through another coil; and it is so sensitive that the action of the earth itself is capaple of setting it north and south.

There is an irresistible tendency to unify in the human mind; and, in accordance with our mental constitution, we desire to reduce phenomena which are so much alike to a common cause. Hence the conception of the celebrated Ampère that a magnet is simply an assemblage of electric currents. Round the atoms of a magnet Ampère supposed minute currents to circulate incessantly in parallel planes; round the atoms of common iron he also supposed them to circulate, but in all directions—thus neutralizing each other. The act of magnetisation he supposed to consist in the rendering of the molecular currents parallel to a common plane, as they are supposed to be in a permanent magnet.

This is the celebrated theory of molecular currents propounded by Ampère. You observe it consists in the application of conceptions obtained from sensible masses of matter to insensible or atomic masses. Let us follow out this conception to what would appear its legitimate consequences. I have said that we obtain both attractions and repulsions from electric currents: all these effects are deduced from one law, which is, *that electric currents flowing in the same direction attract each other, while, when they flow in opposite directions, they repel each other.* Let me illustrate this law rapidly. Here are two flat coils suspended facing each other, and about eight inches apart. I send a current through both, causing it to flow through them in the same direction; the coils instantly clash and cling together in virtue of their mutual attraction. I now reverse the current through one of them, and they fly a yard asunder, in virtue of their mutual repulsion. And now one of them twists its suspending wire so as to turn its opposite face to the other coil; the currents are now again in the same direction, and the coils clash and cling as in the first instance. Imagine, then, our molecular currents flowing round the atoms of this iron bar in planes perpendicular to the length of the bar. From the law just enunciated we should infer the mutual attraction of those currents; and from this attraction we should be disposed to infer the *shortening* of the bar at the moment of magnetisation. Here, for example, is a coil of copper wire suspended vertically; the end of the coil dips into this little basin of mercury. From a small voltaic battery behind I send a current through the coil; and, because it passes in the same direction through all its convolutions, they attract each other. The coil is thereby shortened; its end quits the mercury with a spark; the current ceases; the wire falls by its own gravity; the current again passes, and the wire shortens as before. Thus you have this quick succession of brilliant† sparks produced by the shortening of the wire and the interruption of the current as it quits the mercury.

* The sound, I find, was first noticed by Mr. Page.—J. T., 16th June.

† Rendered brilliant by the introduction of a coil of wire and a core of soft iron into the circuit.

Is it a fact, then, that an iron bar is *shortened* by the act of magnetisation? It is not. And here, as before, we enter into the labours of other men.

Mr. Joule was the first to prove that the bar is *lengthened.* Mr. Joule rendered this lengthening visible by means of a system of levers and a microscope, through which a single observer saw the action. The experiment has never, I believe, been made before a public audience; but the instrument referred to* at the commencement of this lecture will, I think, enable me to render this effect of magnetisation visible to everybody present.

Before you is an upright iron bar, two feet long, firmly screwed into a solid block of wood. Sliding on two upright brass pillars is a portion of the instrument which you see above the iron bar. The essential parts of this section of the apparatus are, first, a vertical rod of brass, which moves freely and accurately in a long brass collar. The lower end of the brass rod rests upon the upper flat surface of the iron bar. To the top of the brass rod is attached a point of steel; and this point now presses against a plate of agate, near a pivot which forms the fulcrum of a lever. The distant end of the lever is connected, by a very fine wire, with an axis on which is fixed a small circular mirror. If the steel point point be pushed up against the agate plate, the end of the lever is raised; the axis is thereby caused to turn, and the mirror rotates. I now cast a beam from an electric lamp upon this mirror: it is reflected in a luminous sheaf, fifteen or sixteen feet long, and it strikes our screen, there forming a circular patch of brilliant light. This beam is to be our index; it will move as the mirror moves, only with twice its angular velocity; and the motion of the patch of light will inform us of the lengthening and shortening of the iron bar.

I employ one battery simply to ignite the lamp. I have here a second battery to magnetise the iron bar. At present no current is passing. I make the circuit, and the bright image on the screen is suddenly displaced. It sinks a foot. I break the circuit: the bar instantly shrinks to its normal length, and the image returns to its first position. I make the experiment several times in succession: the result is always the same. Always when I magnetise, the image instantly descends, which declares the lengthening of the bar; always when I interrupt the current, the image immediately rises. A little warm water projected against the bar causes the image to descend *gradually.* This, I believe, is the first time that this action of magnetism has been seen by a public audience.

I have employed the same apparatus in the examination of bismuth bars; and, though considerable power has been applied, I have hitherto failed to produce any sensible effect. It was at least conceivable that complementary effects might be here exhibited, and a new antithesis thus established between magnetism and diamagnetism.

No explanation of this action has, to my knowledge, been offered; and I would now beg to propose one which seems to be sufficient. I place this large flat magnet upon the table; over it I put a paper screen; and on the screen I shake iron filings. You know the beautiful lines in which those filings arrange themselves—lines which have become classical from the use made of them in this institution; for they have been guiding-threads for Faraday's intelligence while exploring the most profound and intricate phenomena of magnetism. These lines indicate the direction in which a small magnetic needle sets itself when placed on any of them. The needle will always be a tangent to the magnetic curve. A little rod of iron, freely suspended, behaves exactly like the needle, and sets its longest dimension in the direction of the magnetic curve. In fact, the particles of iron filings themselves are virtually so many little rods of iron, which, when they are released from the friction of the screen by tapping, set their longest dimensions along the lines of force. Now, in this bar magnet the lines of force run along the magnet itself, and, were its particles capable of free motion, they also would set their longest dimensions parallel to the lines of force—that is to say, parallel to the length of the magnet. This, then, is the explanation which I would offer of the lengthening of the bar. The bar is composed of irregular crystalline granules; and, when magnetised, these granules tend to set their longest dimensions parallel to the axis of the bar. They succeed, partially, and produce a microscopic lengthening of the bar, which, suitably magnified, has been rendered visible to you.†

Perhaps you do not see the magnetic curves from your present position, but I will enable you to see them. I have here an electric lamp turned on its back, and from it a vertical cylinder of light now issues. Over the aperture of the lamp I place two small bar magnets, enclosed between two plates of glass. The vertical beam is received upon a looking-glass which reflects it on to the screen. In the path of this reflected beam I place a lens, and thus obtain upon the screen a magnified image of the two small bar magnets. And now I sprinkle this fine iron sand on the plate of glass, and you see how it arranges itself under the operation of the magnets. A most beautiful display of the magnetic curves is now before you. And you observe, when I tap the glass, how the particles attach themselves by their ends, and how the curves close in upon each other. They try to attach themselves thus and close thus up in the solid iron bar: the consequence is that the longitudinal expansion is exactly counterbalanced by the transverse contraction, so that the volume of the bar remains unchanged.

But can we not bring a body with movable particles within an electro-magnetic coil? We can; and I will now, in conclusion, show you an experiment devised by Mr. Grove, which bears directly upon this question, but the sight of which, I believe, has hitherto been confined to Mr. Grove himself. At all events, I am not aware of its ever having been made before a large audience. I have here a cylinder with glass ends, and it contains a muddy liquid. This muddiness is produced by the magnetic oxide of iron which is suspended mechanically in water. Round the glass cylinder I have coiled five or six layers of covered copper wire; and here is a battery from which a current can be sent through the coil. First of all, I place the glass cylinder in the path of the beam from our electric lamp, and, by means of a lens, cast a magnified image of the end of the cylinder on the screen. That image at present possesses but feeble illumination. The light is almost extinguished by the suspended particles of magnetic oxide. But, if what I have stated regarding the lines of force through the bar of magnetised iron be correct, the particles of the oxide will suddenly set their longest dimensions parallel to the axis of the cylinder, and also in part set themselves end to end when the current is sent round them. More light will be thus enabled to pass; and now you observe the effect. The moment I establish the circuit the disc upon the screen becomes luminous: I interrupt the current, and gloom supervenes; I re-establish it, and we have a luminous disc once more.

The apparatus, as I have stated, was really invented to examine whether any mechanical effect of this kind could be detected in diamagnetic bodies; but hitherto without result. And this leads me to remark on the large ratio which the failures of an original inquirer bear to his successes. The public see the success—the failure is known to the inquirer alone. The encouragement of his fellow-men, it is true, often cheers the investigator and strengthens his heart; but his main trials occur when there is no one near to cheer him, and when, if he works aright, he must work for duty and not for reputation. And this is the spirit in which work has been executed in this institution, by a man who has, throughout his life, turned a deaf ear to such allurements as this age places within the reach of scientific renown; and it behoves every friend of this institution to join in the wish that *that* man's spirit may continue to live within its walls, and that those who come after him may not shrink from his self-denial while endeavouring to merit a portion of his fame.

* Very skilfully constructed by Mr. Becker.

† My assistant, Mr. Barrett, has just drawn my attention to a paper by M. De la Rive in which this explanation is given. To him, therefore, belongs the entire credit of it.—J. T., June 16.

ON RECENT CHEMICAL RESEARCHES IN THE ROYAL INSTITUTION.

By EDWARD FRANKLAND, ESQ., F.R.S.

Amongst the branches of inquiry that have engaged the attention of chemists during the past fifteen years, there can scarcely be two opinions as to the paramount importance of those investigations, which have had for their object the discovery of the internal structure of chemical compounds, and especially of organic compounds; for it is by thus studying the architecture of these bodies, that we become acquainted with the plans according to which nature herself constructs them under the influence of what we term vitality, and that we are enabled to imitate her operations. The vast number of organic compounds that can now be produced, without the aid of life in any form, some of them even constituting a part of the food of man, affords ample testimony to the importance of this field and the success with which it has been cultivated.

The ultimate analytical composition of a chemical compound affords us little or no information available for the production of that compound, artificially; but the moment the internal arrangement of the atoms becomes known, the constructive process at once suggests itself. Such a problem may be attacked in two distinct ways, either by taking the compound to pieces, or by building it up from it proximate constituents. More than twelve years ago, the speaker had applied the latter or synthetical process to the investigation of organic compounds containing metals, some of the results of which he had communicated to the members on a previous occasion. A like scrutiny must be applied to other families of organic substances, if we are to become equally acquainted with their molecular construction. It was the application of the synthetical process to an important family of organic substances, that had formed the basis of the investigations recently carried on in the chemical laboratory of the institution. In the execution of this work the speaker had been enthusiastically joined by his friend, Mr. Duppa, who bad in an eminent degree contributed to whatever success had attended their labours.

The family of organic acids thus attacked, and which is represented by lactic acid, had for some years past excited the interest and attention of chemists, but although much laborious investigation had been expended upon it, especially by Kolbe and Wurtz, yet the constitution of these acids was still far from being established. Like any effort to overcome a difficulty, such an investigation required the selection of a plan of attack, and the preparation of the agents, or weapons, by which the assault was to be made. The speaker had already proved in a paper communicated to the Royal Society, that oxalic acid was the basis or model of the family of acids to be investigated. This fact showed the path by which the subject was to be approached, and he then went on to describe the principles according to which the weapons were constructed.

In mechanics, the engineer proportions the force which he employs to the effect required to be produced, and it was considered one of the greatest achievements in such control of mechanical force, when Mr. Nasmyth's steam-hammer could be made, at one moment to deliver a blow gentle enough to break the shell of a nut without crushing the kernel, and at the next to descend with a force sufficient to smash a block of granite and shake the ground beneath it. As in mechanics, where we deal with masses, so in chemistry, where we have to do with atoms, it is also necessary to apply a properly graduated amount of force, and to apply it in the right direction. Chemistry was yet far behind mechanics in this faculty of graduating force, but by availing ourselves of certain chemical reactions, we had the power, as it were, of gradually storing up force in the atoms of bodies, and of delivering the blow when the force had become strong enough to effect the change required. In this way the comparatively inert radicles or molecules, methyl, ethyl, amyl, &c., could be invested with chemical energy sufficient to force their entrance into oxalic acid. The process of thus endowing these radicles with force was likened to the gradual winding up of a weight to the height necessary for the production of a given effect by its subse-

quent fall. For this purpose a force external to the atoms to be elevated was obviously required. The first supply of this force was taken from sodium; but sodium, although competent to raise the molecules of ethyl or methyl to a great elevation, was yet too rough in the use of its power, for if we attempted, by its sole agency, to elevate these molecules, they were actually torn to pieces by the violence of the effort. The action of the sodium must, therefore, be moderated by combining it with mercury; much of its power was thus lost, but sufficient still remained for the purpose, if rightly employed.

This sodium amalgam on being brought into contact with the iodides of methyl, ethyl, or amyl refused to exert any action, but on the addition of a few drops of acetic ether, which acted in this case like a ferment, the sodium separated the iodine from the ethyl, whilst the latter united itself with the mercury.

$$\underbrace{2C_2H_5I}_{\text{Iodide of Ethyl}} + \underbrace{Hg\left\{\begin{matrix}Na\\Na\end{matrix}\right.}_{\text{Sodium Amalgam}} = \underbrace{Hg\left\{\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right.}_{\text{Mercuric Ethide}} + \underbrace{2NaI}_{\text{Iodide of Sodium}}$$

By this association with mercury, the energy of the ethyl was greatly increased, but it still lacked sufficient power for its attack upon oxalic acid; having once commenced its ascent, however, the further elevation of the ethyl became comparatively easy. It was only necessary to digest the mercuric ethide, procured as above described, with metallic zinc, at a temperature of 100° C. for several hours, in order to replace the mercury with zinc, by which means zinc ethyl was obtained.

$$\underbrace{Hg\left\{\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right.}_{\text{Mercuric Ethide}} + Zn. = \underbrace{Zn.\left\{\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right.}_{\text{Zinc Ethyl}} + Hg$$

The zinc ethyl thus obtained possessed far greater energy than the mercuric ethide from which it was derived,* and, in fact, in this compound, the ethyl became fully armed for the contemplated expedition. The speaker, however, showed that its power could be still further increased by the addition of the metal lithium. By these processes the following chemical compounds and weapons of attack had been manufactured:—

Name.	Formula.
Mercuric Methide	$Hg\left\{\begin{matrix}CH_3\\CH_3\end{matrix}\right.$
Mercuric Iodo-methide	$Hg\left\{\begin{matrix}CH_3\\I\end{matrix}\right.$
Mercuric Ethide	$Hg\left\{\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right.$
Mercuric Iodo-ethide	$Hg\left\{\begin{matrix}C_2H_5\\I\end{matrix}\right.$
Mercuric Chlor-ethide	$Hg\left\{\begin{matrix}C_2H_5\\Cl\end{matrix}\right.$
Mercuric Amylide	$Hg\left\{\begin{matrix}C_5H_{11}\\C_5H_{11}\end{matrix}\right.$
Mercuric Iod-amylide	$Hg\left\{\begin{matrix}C_5H_{11}\\I\end{matrix}\right.$
Mercuric Chlor-amylide	$Hg\left\{\begin{matrix}C_5H_{11}\\Cl\end{matrix}\right.$
Zincmethide	$Zn\left\{\begin{matrix}CH_3\\CH_3\end{matrix}\right.$
Zincethide	$Zn\left\{\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right.$
Zincamylide	$Zn\left\{\begin{matrix}C_5H_{11}\\C_5H_{11}\end{matrix}\right.$
Lithio-mercuric Methide	$\begin{matrix}Hg''\\Li'\end{matrix}\left\{\begin{matrix}CH_3'\\CH_3'\\CH_3'\end{matrix}\right.$?
Lithio-mercuric Ethide	$\begin{matrix}Hg''\\Li'\end{matrix}\left\{\begin{matrix}C_2H_5'\\C_2H_5'\\C_2H_5'\end{matrix}\right.$?
Lithio-zinc Methide	$\begin{matrix}Zn''\\Li'\end{matrix}\left\{\begin{matrix}CH_3'\\CH_3'\\CH_3'\end{matrix}\right.$?
Lithio-zinc Ethide	$\begin{matrix}Zn''\\Li'\end{matrix}\left\{\begin{matrix}C_2H_5'\\C_2H_5'\\C_2H_5'\end{matrix}\right.$?

The speaker then described the action of several of these bodies upon oxalic acid, or rather oxalic ether. This action consisted in the removal of one atom of oxygen from oxalic acid, and its substitution by two atoms of ethyl, methyl, &c. Thus, by the action of zincethyl, oxalic acid was transformed into leucic acid—a body that had previously been obtained from animal tissues, especially from the spleen and lungs. By acting upon oxalic ether with the zinc compounds of other organic radicles, a large number of acids belonging to the lactic series, and hitherto unknown, could be produced. Many of these acids were isomeric with each other, that is, possessed the same per centage composition, but differed in their interior architecture. Thus leucic acid was susceptible of no less than nine isomeric modifications, three of which had already been obtained by the method now described. The following table shows the internal structure of these isomeric leucic acids:—

$C_2'''\left\{\begin{matrix}C_2H_5'\\C_2H_5'\\O''\\OH'\\OH'\end{matrix}\right.$	$C_2'''\left\{\begin{matrix}C_2H_5'\\H'\\O''\\OC_2H_5'\\OH'\end{matrix}\right.$	$C_2'''\left\{\begin{matrix}C_2H_5'\\CH_3'\\O''\\OCH_3'\\OH'\end{matrix}\right.$
$C_2'''\left\{\begin{matrix}CH_3'\\CH_3'\\O''\\OC_2H_5'\\OH'\end{matrix}\right.$	$C_2'''\left\{\begin{matrix}C_3H_7'\\CH_3\\O''\\OH'\\OH'\end{matrix}\right.$	$C_2'''\left\{\begin{matrix}C_3H_7'\\H'\\O''\\OCH_3'\\OH'\end{matrix}\right.$
$C_2'''\left\{\begin{matrix}CH_3'\\H'\\O''\\OC_3H_7'\\OH'\end{matrix}\right.$	$C_2'''\left\{\begin{matrix}C_4H_9'\\H'\\O''\\OH'\\OH'\end{matrix}\right.$	$C_2'''\left\{\begin{matrix}H'\\H'\\O''\\OC_4H_9'\\OH'\end{matrix}\right.$

The following is a list of acids which, with their compounds, have thus been produced and investigated during the past year in the laboratory of the Institution:—

Name.	Formula.
Dimethyloxalic Acid No. 1	$C_2'''\left\{\begin{matrix}CH_3'\\CH_3'\\O''\\OH'\\OH'\end{matrix}\right.$
Dimethyloxalic Acid No. 2	$C_2'''\left\{\begin{matrix}CH_3'\\H'\\O''\\OCH_3'\\OH'\end{matrix}\right.$
Leucic Acid No. 1	$C_2'''\left\{\begin{matrix}C_2H_5'\\C_2H_5'\\O''\\OH'\\OH'\end{matrix}\right.$
Leucic Acid No. 2	$C_2'''\left\{\begin{matrix}C_2H_5'\\CH_3'\\O''\\OCH_3'\\OH'\end{matrix}\right.$
Leucic Acid No. 3	$C_2'''\left\{\begin{matrix}CH_3'\\CH_3'\\O''\\OC_2H_5'\\OH'\end{matrix}\right.$
Ethyl-amyl Oxalic Acid	$C_2'''\left\{\begin{matrix}C_5H_{11}'\\C_2H_5'\\O''\\OH'\\OH'\end{matrix}\right.$
Diamyl-oxalic Amyl-ether	$C_2'''\left\{\begin{matrix}C_5H_{11}'\\C_5H_{11}'\\O''\\OH'\\OC_5H_{11}'\end{matrix}\right.$

These reactions proved that lactic acid, the representative of this family of acids, was also cast in the mould of oxalic acid. Thus, the latter deadly organic body was converted by the removal of one atom of oxygen and its substitution by one of hydrogen and one of methyl into the harmless acid of sour milk, a constituent of the juices of the human body, and an agent, no doubt, of importance in the transformations attending animal life. A similar marvellous transmutation of character is met with in the highly poisonous arsenic acid, which, by the exchange of one atom of oxygen for two of methyl, is converted into the innocuous, though perfectly soluble, cacodylic acid.

The speaker concluded as follows:—Here, then, we have a most prolific reaction, capable of furnishing an immense number of new organic bodies, and at the same time indicating to us the very simple manner in which nature evolves some of her, apparently, most complex results. By a species of progressive development, this simply organised oxalic acid becomes gradually elevated, cultivated, and transformed into bodies, which, when viewed by one ignorant of their true origin, appear to possess a hopeless complexity. Not only do we now gain a clear insight into the architecture of these acids, but we can take the very elements of which they are composed, and build them up unaided by any vital processes. We need not even go for oxalic acid, our very type or model, either to the wood-sorrel, or the lichen, which, by means of this acid, corrodes the rock upon which it grows; for we have the power both to lay the foundation and to build the superstructure of these organic bodies, without the least assistance from either animal or vegetable life. And is it too much to hope, that, by analogous inductive scrutiny, even the most obscure and complex physiological phenomena of life itself will one day yield to scientific research, and become to us as clear and simple as they are now dark and unintelligible? But to accomplish

* The intense chemical energy of zinc ethyl was shown experimentally by a fountain of the liquid, which played perpendicularly to the height of 6ft. or 8ft., forming a fiery jet of blue and white flame.

this, the human intellect must prepare itself for efforts far more difficult than any it has yet made. Hitherto the more palpable and simple phenomena of nature have been the first to attract the attention of philosophers, whilst the more recondite and hidden, constituting increasingly difficult subjects of research have been left for future explorers. Thus although we are still scarcely advanced beyond the condition of children gathering pebbles on the shore of the boundless ocean of knowledge, yet those pebbles, never easy to find, are now no longer left dry on the beach. They must be dragged from the grip of the waves by patient and cunning toil. Difficulties innumerable and appalling confront us, but let the human intellect be only left free and untrammelled, and it will surely accomplish the task set before it.

ON THE CLASSIFICATION OF THE ELEMENTS IN RELATION TO THEIR ATOMICITIES.

By PROFESSOR ALEXANDER W. WILLIAMSON, F.R.S.

The speaker proposed to bring under the consideration of the members some of the chemical grounds for doubling the atomic weights of all the metals in Gerhardt's system of atomic weights, excepting the alkali metals, silver, gold, boron, and the metals of the nitrogen series. A change which has been proposed mainly on physical grounds by Carmizzaro, and which seems to be obtaining the approbation of more and more chemists.

TABLES OF ATOMIC WEIGHTS.

1st Class of Elements, which only furnishes an even number of atoms to each Molecule :—

Fl	= 19	H	= 1	N	= 14
Cl	35·5	Li	= 7	P	31
Br	80	Na	= 23	As	75
J	127	K	= 39	Sb	122
		Rb	= 85	Bi	210
		Cs	133	B	11
		Tl	203	Au	196
		Ag	108		

2nd Class of Elements, which sometimes furnishes an odd, sometimes an even number of atoms to one Molecule :—

O	= 16	C	= 12	G	= 9
S	= 32	Si	28	Yt	64
Se	79·5	Ti	50	Ce	92
Te	129	Sn	118	La	92
Ca	40	Mo	96	Dy	96
Sr	87·5	V	137	U	120
Ba	137	W	184	Zr	89·5
Pb	207	Pt	197	Ta	138
Mg	24	Tr	= 197	Cb	195
Zn	65	Os	199	Th	238
Cd	= 112	Ro	104		
Hg	200	Ru	104		
Al	27·5	Pd	106·5		
Fe	56				
Cr	52·5				
Mn	55				
Co	58·5				
Ni	58·5				
Cu	63·5				

It is now about twenty years since Gerhardt drew attention to the error of the molecular weights, or equivalent weights, as he called them, which represented water as consisting of one atom of oxygen and one of hydrogen, and proposed to double the atomic weights of oxygen and of carbon.

If Gerhardt had taken Berzelius's atomic weights and, while translating them into the hydrogen scale, had halved the atomic weights of the alkali metals and boron, he would have given us at once the system which we now adopt, saving the rectification of a few formulæ, such as that of silver and oxide of uranium, &c.; whereas, by merely doubling oxygen, sulphur, selenium, and carbon, in the then existing system of atomic weights in the hydrogen scale, he really introduced a system in which there are between 30 and 40 atomic weights to correct, in lieu of one which needed only five or six such corrections. It would be unreasonable to apply this fact in any degree to the disparagement of Gerhardt's work. It only shows how tortuous is the road which leads to truth.

The discussion of the question involves chiefly the consideration of the classification of the elements under the respective heads of chlorine and of oxygen.

The first tribe containing those elements of which an atom combines with one atom of hydrogen or chlorine, or with three or with five, &c., whilst the second tribe contains elements of which each atom combines with two atoms of chlorine, or other monads, or with four, or six, &c. The speaker did not, however, recommend that the two great classes of elements he thus distinguished from one another, for our chief evidence of atomic weights is derived from the study of the molecular weights of compounds, and the molecule is the unit to which results must be referred.

The first class is best described as furnishing only an even number of atoms to each molecule, whereas the second class sometimes furnishes an even, sometimes an uneven number of atoms to one molecule. The process of classifying the elements has followed the very natural order of establishing a certain number of well-defined families, which were subsequently connected together by erratic members, which occasionally left their usual place to go over to some neighbouring family. Chlorine, bromine, and iodine have long been acknowledged to constitute a natural family; and there are some, though hardly sufficient reasons for placing fluorine at its head. The three elements have the same vapour volume as hydrogen in the free state, and we accordingly represent their respective molecules as Cl^2, Br^2, I^2, corresponding to $H^2 = 2$ vols. They form hydrides of similar composition, and analogous properties, and of the same vapour volume. Their compounds with most metals are analogous and have the same atomic heat and general crystalline form. Their corresponding oxygen acids also exhibit considerable analogy.

With organic radicles they form neutral ethers, like $Cl\,C^2\,H^5$, $Cl\,C^2\,H^3\,O$, and no acid ethers. So that when a molecule of alcohol or of acetic acid is replaced by chlorine, two atoms of chlorine take the place of one atom of oxygen, and give rise to a molecule of chloride of ethyle and a molecule of hydrochloric acid. They replace hydrogen atom for atom, taking out one, two, or three atoms, &c., according to circumstances. Their hydrogen compounds are all monobasic acids; for if, in a given quantity of hydrochloric or hydrobromic hydriodic acid, we replace part only of the hydrogen by potassium, we get at once a neutral salt mixed with the remaining acid, which is undecomposed, and never an acid salt of the alkalies. Fluorine in this respect exhibits an anomaly which tends to remove it from this family to a biatomic one. For the acid fluoride of potassium is a well-defined compound of considerable stability, of which the existence points to the atomic weight 38 for fluorine, and the formula $H^2\,F$ for hydrofluoric acid. Hydrofluoric acid, moreover, combines with various metallic fluorides—such as fluoride of silicon and fluoride of boron; and there are double fluorides of aluminium, &c., with alkaline fluorides, both well known and easily formed.

Similar double salts are, however, formed by chlorine; for instance, terchloride of gold combines with a molecule of hydrocloric acid, or of an alkaline chloride. Tetrachloride of platinum combines with two molecules of hydrochloric acid or of chloride of potassium, &c.

It is not possible to reconcile the constitution of these and similar bodies with one another and with the simpler compounds of chlorine, by any theory representing it as polyatomic, and as holding together the metallic atoms in these salts in virtue of its polyatomic character. On the other hand, hydrochloric acid and metallic chlorides of opposite properties cannot be assumed to be incapable of uniting with one another, while it is well known that oxides of basylous properties unite with those of chlorous properties. Hydrochloric acid unites with ammonia, and we do admit that the two molecules are bound together into one by a chemical force of combination, and not by any tetratomic character of the hydrogen; and HCl or KCl combines with SO^3 by a similar force.

Again: oxygen, sulphur, selenium, and tellurium are admitted to be truly analogous elements, for the parallelism of oxygen salts, and sulphur salts, affords abundant proof of the analogy of oxygen and sulphur, and the molecular volume of sulphur and selenium is found by Deville to agree at high temperature with that of oxygen.

The elements selenium and tellurium form acids analogous to sulphurous and sulphuric acids respectively. When combined with organic radicals they form compounds of the same molecular volume in the form of vapour; and when any of them, such as oxygen, replaces hydrogen in an organic body, it takes out two atoms of hydrogen at a time, replacing each couple by one atom of oxygen, as in the formation of acetic acid from alcohol.

When we partially decompose water by potassium we get hydrate of potash formed, which is a molecule of water, from which half the hydrogen is expelled, and replaced by potassium, and a second atom of potassium is required to displace the remaining hydrogen.

If we compare any proto-chloride with a corresponding oxide, either of a metal or organic radical, we find that the molecule of the oxide contains twice as many atoms of the metal or radical as the chloride, and that one atom from the oxygen family is equivalent to two atoms from the chlorine family.

When oxygen in alcohol is replaced by sulphur, no breaking up into sulphide of ethyle and sulphide of hydrogen takes place, as when the oxygen is replaced by chlorine or bromine.

Among the best known compounds there are several of which one atom combines, like an atom of oxygen or of sulphur, with two atoms like hydrogen or chlorine. Thus carbonic oxide, sulphurous acid, and olefiant gas are capable of combining in the proportion of one atom of the radical with two atoms of chlorine, forming the compound $C\,O\,Cl^2$ phosgene, $So^2\,Cl^2$ chloro-sulphuric acid, and $C^2\,H^4\,Cl^2$ Dutch liquid; and these molecules have the same vapour volume as steam $O\,H^2$. But in the free state the radicals have a vapour volume double as great as the equivalent quantity of oxygen, the atoms $C\,O$, $S\,O^2$, $C^2\,H^4$ being as bulky as O^2, so that whereas the molecule of oxygen and of sulphur consists of two atoms, that of carbonic oxide consists of one atom only, so also the molecule of sulphurous acid and of olefiant gas.

Another family of very marked characteristics is that consisting of N, P, As, Sb, Bi, each member of which combines with three atoms of hydrogen or of ethyle ($C^2\,H^5$), forming basic compounds analogous to ammonia. Their analogy in chemical reactions is also well known, as each of them forms an oxide corresponding to nitrous acid, and another corresponding to nitric acid.

The sulphides of arsenic and antimony are notorious for their great resemblance, and that of arsenious acid and antimonious is scarcely less striking. It even extends to isomorphism of their corresponding salts.

The atomic heat of the four last terms of the series is also very nearly the same, whilst that of nitrogen (examined of course as a gas) is considerably less. Then the molecule of phosphorus and of arsenic consists of four atoms, whilst that of nitrogen consists only of two, showing a variety of constitution, which is by no means to be wondered at, when we recollect that these elements are not uniformly triatomic, but sometimes monatomic, pentatomic, &c., so that the molecule of free nitrogen consists of two monatomic atoms, or two triatomic, whilst the molecule of phosphorus and of arsenic is formed on the ammonia type of one triatomic atom and three monotomic atoms.

Another family may, perhaps, be made up of carbon and silicon, both of which

form volatile tetrachlorides, and are somctimes biatomic, sometimes tetratomic in their acids.

Among metals, lithium, sodium, potassium, and probably also the new metals, rudidium, cæsium, and thallium, have many important points of resemblauce which show them to be mouatomic. They replace hydrogen atom for atom, aud form with many bibasic acids both normal and acid salts. Their chlorides form with tetra-chloride of platinum aualogous double salts, aud their sulphates form, with sulphate of alumina, &c., those well-characterized salts called alums. They do not form basic salts (uuless when triatomic, like thallium). They have nearly the same atomic heat.

Silver is remarkable for several of the properties which we have noticed in the alkali metals. It is eminently monatomic, aud disiuclined to form basic salts. Its atomic heat also shows it to be monatomic. It appears to form an alum, aud its sulphate has a great resemblauce of form with the anhydrous sulphate of soda.

Gold also must from its specific heat, aud the constitution of its two chlorides be classed among the metals which are monatomic or triatomic. Boron is evidently triatomic in its best knowu compounds, as proved by the ter-chloride and ethylide.

Among metals with strongly basylous properties, Ca, Sr, Ba, Pb, arc connected by very close analogies. The general resemblance of their sulphates and carbonates, and the isomorphism of most of them, are too well kuown to need mention.

But lead has beeu obtained in combiuation with ethyle, and the compound $Pb (C^2 H^5)^4$ which correspouds to binoxide of lead, in which the two atoms of oxygen are replaced by four atoms of ethyle, and the compound $Pb (C^2 H^5)\, ^3Cl$ proves beyond a doubt that the metal is there tetrabasic.

Agaiu, lead is prc-emineut for its tendency to form basic salts even with purely monatomic chlorons elements and radicals. Thus ordiuary nitrate of lead, when warmed in aqneous solutiou with ceruse, expels carbonic acid from that compouud, and forms the well-known and crystallizable basic nitrate—$Pb \left\{ \begin{matrix} N\ O^3 \\ H\ O. \end{matrix} \right.$ If this be represeuted upou the water type, it is formed from two molecules of water, $\begin{matrix} H \\ H \end{matrix} O \quad \begin{matrix} H \\ H \end{matrix} O$ two atoms of hydrogen, one from each moleculc being replaced by the biatomic atom lead, whilst one of the remaining atoms of hydrogen is replaced by $N O^2$, thns $\begin{matrix} NO^2 \\ Pb \\ H \end{matrix} \begin{matrix} O \\ O \end{matrix}$

But if the binary theory be adopted, it must be represeuted as lead combined with the radical $N O^3$, and also with the radical $H O$, and the biatomic lead holds thus two atoms together, just as much as biatomic oxygeu holds together ethyle and hydrogen in alcohol. If we mix our lead compouud with sulphate of silver, aud heat with water, we replace the one atom of lead in it by two atoms of silver, getting a mixture of nitrate of silver aud brown hydrated oxide of silver just as the replacement of oxygen in alcohol by Cl^2 forms chloride of ethyle + hydrochloric acid.

We are thus led to consider these metals as biatomic, and to represent their oxides, by the old formulæ $Ca O$, $Ba O$, $Pb O$, whilst carbonates, sulphides, and sulphates have formulæ like $Ca C O^3$, $Ca S O^3$, $Ca S O^4$, their chlorides, nitrates, and phosphates have formulæ likc $Ca Cl^2$, $Ca (N O^3)^2$, $Ca^3 (P O^4)^2$. Nitrate of potash has thus a similar formula ($N O^3 K$) to arragonite $C O^3 Ca$, and their isomorphism is no louger surprisiug. The same remark applies to calc spar and nitrate of soda.

Another analogous group of metals is the triad, magnesium, zinc, and cadmium, all volatile and forming salts which greatly resemble one another, and in many cases isomorphous. The constitutiou and properties of Frankland's zinc ethyle leaves uo doubt of the biatomic character of zinc, for the compound $Zn (C^2 H^5)^2$ has the same molecular volume as ether $O (C^2 H^5)^2$, and if the atom of zinc were taken out and replaced by one atom of oxygeu, there would be no change of volume. Then half the ethyle in zinc ethyle is replaceable by iodine, jnst as half the ethyle in ether is replaceable by potassium.

The biatomic character of this family beiug thus established, we can extend the conclnsion to the other metals which form magnesiau oxides, so called from the striking analogy of constitutiou of several of their salts with the corresponding salt of magnesia. In this mauner we are led to adopt for irou, mauganese, uickel, cobalt, and copper atomic weights corresponding to biatomic characters. The subsulphide of copper is thus represeuted by the formulæ $Cu^2 S$, which is sufficiently similar to that of sulphide of silver $Ag^2 S$, to remove our surprise at their isomorphism. There is, moveover, in the reactions of alumina, sesqui-oxide of iron, sesqui-oxide of chromium, and sesqui-oxide of mangauese, much resemblance. All these are weak bases, and their sulphates form with sulphate of potash those most characteristic salts called alums. The three first are isomorphous in the uncombined state, so that the conclusion established for iron and mangauese may be extended to aluminium aud chromium. But it is also arrived at by other means, for chromium in combination with oxygen and chlorine, forms the well-characterised compound $Cr O^2 Cl^2$ chloro-chromic acid, which contains the same quautity of oxygen and of chlorinc as chloro-sulphuric acid in two volumes of vapour, having 52·5 of chromium in the place of the 32 of sulphur of that compouud. Again, chromic and sulphuric acids exhibit a marked resemblauce of properties, the former being, if anything, even more distinctly bibasic than the latter, and their normal potash salts are isomorphous, so that chromium is abundautly proved to be similar to sulphur in atomicity, and brings in evidence of its owu in favour of the biatomic character of aluminium, iron, aud manganese. Iu like manner manganese in manganic acid is connected with sulphnr in sulphnric acid, and requires a correspondiug biatomic weight. The isomorphism aud general analogy of permauganate of potash with per-chlorate of potash has often been alluded to as pointing to the uecessity of representing the former by a formula containing one large atom of manganese, $Mu O^4 K$; but although this formula, by assimilating the expressions for these two similar bodies, removes one difficulty, it creates at the same time another difficulty, by presenting a formula containing only oue atom from the first family of elements. The speaker said he would not at preseut hazard any opiuion regarding the propriety of removing this difficulty by doubling the above formula, together with that of per-chlorate of potash, although he might remark that the constitution of the basic per-iodate of soda points to the formula $I^2 O^9 Na^4\, 3 (H^2 O)$.

An exceedingly strong ground for admitting for many heavy metals the atomic weight corresponding to a biatomic character was brought forward some time ago by Wurtz, who pointed out that adopting for oxygen the atomic weight 16, we get a half-molecule of water $\frac{H^2 O}{2}$ in one molecule of various salts if we consider the heavy metals monatomic.

Other mctals are susceptible of reduction by similar aualogies to the class of elements which are biatomic or tetratomic, &c. Thus mercury is proved by the ethylide aud mcthylide to be biatomic by the fact that the compound for one atom of mcrcury with two atoms of ethyle or of methyle, occupies the same volume in the state of vapour as the compound of one atom of oxygeu with two of ethyle or of methyle $Hg (C H^3)^2 = 2$ vols., aud we can takc out oue atom of methyle from the bi-methylide of mercury, and replace it by an atom of chloriue, bromine, or iodine without disturbing the type, $\begin{matrix} C H^3 \\ I \end{matrix} Hg$. The commou bi-chloride of mercury has, moreover, a vapour volume correspondiug to thc biatomic character of the metal, aud the samc thing holds good of the vapour of metallic mercury itself, which has the same volume as the metal cadmium, and probably zinc, aud the well-known biatomic radicals $C O$, $S O^2$, $C^2 H^4$, but doublc the volume of the elemeuts oxygen and sulphur. In the present state of our knowledge the speaker was not aware of any sufficieut grounds for deciding which of these two constitutions of the free molecule of a biatomic element or radical is to be considered as normal and which is abuormal. Ou the one hand, mercury, cadmium, and all known biatomic radicals have a molecule contaiuiug onc atom, while the moleculc of oxygen contaius two atoms, and that of sulphnr two at high temperatures and six at lower temperatures. Sclenium is at high temperatures like sulphur. It has been amply shown by Dr. Odliug aud others that tin is biatomic and tetratomic in its two chlorides, and its compouuds with the organic radicals and chlorine, &c., leave no room for doubt on the point.

By similar chaius of evidence the remaining metals can be shown to belong to the great biatomic class containing already so many.

The vapour densities of the so-called sesqui-chlorides of iron, aluminium, and chromium, as determined by Deville, show that the molecule of each of these bodies contains two atoms of metal and six atoms of chlorine, in fact the same quautity of metal as the molecule of the sesqui-oxide: this fact has been held to be an anomaly from the point of view adopted regarding their atomic weights. The speaker believed, however, that so far from beiug anomalous, these vapour densities are the least which can be recouciled with the couclusion that thc metals permanently combine with even numbers of atoms from the first family, for if one atom of irou could ou occasion combine with three atoms of chlorine to form oue molecule, the law respecting it would assume the not very wise form—that iron combines with an cven number of atoms from the first family, except when it combines with an uneven number

The fact is, that the sesqui-chlorides are uot exceptious to the law, as at first sight they are suspected of being. Precisely the same remarks apply to thc so-called subchloride of sulphur of which the molecule is $S^2 Cl^2$, as required by the law. So also cyanogen $C^2 N^2$, acetylene $C^2 H^2$, ethyle $C^4 H^{10}$, &c., &c. Amongst exceptions, thc speakcr meutioued uitric oxide and calomel, both of which have vapour densities correspondiug to the molecular formulæ $N O$ aud $Hg Cl$.

Mauy compounds are known to undergo decomposition on evaporation, and to be reproduced on condeusation; thus $N H^5 O$ yields the two molecules $N H^3$ and $H^2 O$, each with its own volume, as also $S O^3 H^2$ yields $S O^2$ aud $H^2 O$. $S O^4 H^2$ and $P Cl^5$ are also known to yield on evaporation vapour corresponding to a breaking-np iuto two molecules; and there are strong reasons from analogy, as well as experimental evidence, to believe such decomposition. As, however, a high authority seems inclined to doubt the decompositiou, the matter may be cousidered as still *sub judice*.

The existence of basic salts of mercury or copper, when apparently mouatomic, is another class of apparent excoptious to the law. For if, iu the sub-nitrate of mercury, the atom of metal really replaced one atom of hydrogen, just as potassium does in nitrate of potash, there ought not to be basic sub-uitrate of mercury, any more than a basic potash salt; whereas if the sub-uitrate of mercury contains, as the speaker asserted, in oue molecule two atoms of metal and two atoms of the salt radical of the nitrates ($N O^3$), theu a basic salt is as natural and intelligible a compound as the basic uitrate of the red oxide.

The actiou of ammonia ou calomel confirms the molecular weight $Hg^2 Cl^2$; for the compouud $N H^2 Hg^2 Cl$, formed simultaneously with sal ammouia, proves that twice ($Hg Cl$) takes place in thc reaction.

INDIA RUBBER TELEGRAPH WIRES. — There are now in course of manufacture, for Government telegraphs, India rubber covered wires, which consist of a No. 18 (diameter ·043) tinned copper, insulated to a total diameter of ·55in. Weight of copper, per mile, 30lb.; weight of insulator, per mile, 60lb. The resistance of the insulating medium for one mile, tested in water at a temperature of 60° Fahr., is 4,750,000 Siemen's units; and the resistance of the conductor 54 Siemen's units. The insulation tests, both static and dynamic, appear to be of a high character in comparison with results obtained on other materials. No tar is to be applied to this ore, on account of its deteriorating effects when brought into contact with the rubber.

INSTITUTION OF CIVIL ENGINEERS.

The following is the list of premiums awarded by the Council for the Session 1863–64:—

1. A Telford medal, and the Manby premium, in books, to George Henry Phipps, M. Inst. C.E., for his paper "On the Resistances to Bodies passing through Water."

*2. A Telford premium, in books, to John Baldry Redman, M. Inst. C.E., for his paper "On the East Coast, between the Thames and the Wash Estuaries."

3. A Telford medal, and a Telford premium, in books, to William Lloyd, M. Inst. C.E., for his "Description of the Santiago and Valparaiso Railway, Chile, South America; with remarks upon resistances from curves on railways, and upon coal-burning locomotives."

*4. A Telford premium, in books, to William Parkes, M. Inst. C.E., for his "Description of Lighthouses lately erected in the Red Sea."

5. A Telford medal, to M. Peruolet (of Paris), for his paper "On the means of utilising the products of the Distillation of Coal, so as to reduce the price of Coke; with descriptions of the Ovens, and of the best processes in use in Great Britain and on the Continent, in the Manufacture of Coke."

6. A Watt medal, and a Telford premium, in books, to Thomas Sopwith, jun., Assoc. Inst. C.E., for his paper "On the Actual State of the Works on the Mont Cenis Tunnel, Victor Emmanuel Railway, and Description of the Machinery employed."

*7. A Watt medal, to William Bridges Adams, for his paper "On the Impedimental Friction between Wheel Tires and Rails, with plans for Improvement."

8. A Watt medal, to James Cross, for his paper "On the Structure of Locomotive Engines for ascending Steep Inclines, especially when in conjunction with Sharp Curves on Railways."

*9. A Telford premium, in books, to John Mortimer Heppel, M. Inst. C.E., for his paper "On the Closing of Reclamation Banks."

10. A Telford premium, in books, to George Rowdon Burnell, F.G.S., for his paper "On the Machinery employed in sinking Artesian Wells on the Continent."

THE ROYAL SOCIETY.

INQUIRIES INTO THE NATIONAL DIETARY.

By Dr. E. Smith, F.R.S.

The paper contains an abstract of the scientific results of an inquiry which the author had undertaken for the Government into the exact dietary of large classes of the community, viz., agricultural labourers, cotton operatives, silk-weavers, needlewomen, shoemakers, stocking-weavers, and kid-glovers. The inquiry in reference to the first-class was extended to every county in England, to North and South Wales and Anglesea, to the West and North of Ireland, and to the West, North, and part of the South of Scotland, whilst in reference to the other classes it was prosecuted in the towns where they were congregated.

The object of the investigation was to ascertain in the most careful manner the kind and quantity of food which constitutes the ordinary dietary of those populations; and the inquiry was in all cases made at the homes of the operatives.

The number of families included in the inquiry was 691, containing 3,016 persons then living and taking food at home. The calculations of the nutritive elements are made upon the basis of an adult, two persons under the age of 10 and one over that age being regarded as an adult, and of the elements, the carbon and nitrogen are calculated in each article of food, whilst the free hydrogen is separately estimated as carbon upon the total quantities.

The author then cites the estimations which in his papers in the Philosophical Transactions for 1859 and 1861 he had made of the quantity of carbon and nitrogen emitted by the body under various conditions, and computes on those bases the amounts of those substances which are required as food by various classes of the community. He then proceeds to state the quantities which have been actually found in the dietaries of the persons included in this investigation, and the great variations which the inquiry had brought to light. He also compares the nutriment with the cost of it in the food, and states the proportion which the nitrogen bears to the carbon in each of the classes and in the different localities.

Each article of food is then considered separately, and the frequency with which, as well as the average quantity in which, it was obtained by these populations is stated.

DESCRIPTION OF A NEW MERCURIAL GASOMETER AND AIR PUMP.

By T. R. Robinson, D.D., LLD., F.R.S., &c.

In some experiments on the electric spectra of metal and gases, I felt the want of a mercurial gasometer for working with such of the latter as are absorbable by water. That of Pepys is on too large a scale for my requirements, and it seemed better to contrive one more easily manageable, which I saw could also be made to act as a mercurial air pump. In this I have succeeded to my satisfaction; and I hope that a description of it may be useful to those who are engaged in similar researches.

There have been several attempts made to exhaust by means of mercury, the chief of them with which I am acquainted being those of Close (Nicholson's Journal, 4to, iii. p. 264), Edelkrantz (Nicholson, 8vo, vii. p. 188), Traill and Children (Nicholson, xxi. pp. 63 and 161), and that of Geisler, which he uses in preparing the beautiful vacuum-tubes which bear his name. In all the principle is the same. A vessel is filled with mercury, which is made to descend from it, leaving in it a Torricellian vacuum; this vessel may be made to communicate with a receiver, and abstract from it a portion of the gas which fills it; and by repeating the process the receiver can be exhausted as by successive strokes of an air pump. In the two first instruments to which I have referred, the descent of the mercury is produced by lifting a plunger which fills one leg of an inverted siphon, the vacuum vessel being at the top of the other leg. On depressing the plunger, the mercury is again forced up to fill that vessel; and of course both legs must be longer than the barometric column. In the two next, the receiver itself is filled with mercury, which, by opening a cock, falls through a tube of sufficient length into a cistern below. Here the stroke (so to call it) cannot be repeated. In Geisler's the bend of the siphon is of vulcanised caoutchouc, so that one leg can be inclined down to a horizontal position, and thus allow the metal to fall from the other, or when raised to the vertical position fill it again. This I believe acts well, but it must be rather unwieldy; and my practical acquaintance with the working of tubes of that material has made me suspicious of their tightness and permanence under such circumstances.

As in all these cases the mercury is supported in the vacuum vessel by atmospheric pressure, it is obvious that its descent will be produced by removing in any way that pressure; and an effective means of doing this is supplied by the common air pump; more tedious certainly than the mechanical means above mentioned, but far more manageable; and as any mercurial pump must be slow in its working, while it is only required for special purposes, this defect is not of much importance, and, moreover, is compensated by some special advantages.

But besides bringing down the mercury, means must be provided for raising it again. My first plan was to do this by condensed air, the same syringe which made the exhaustion having its action reversed by a well-known arrangement. It worked extremely well, was lighter, and required less mercury than the contrivance which I finally adopted; but it is less convenient for gasometric work, as the syringe must be worked while gas is delivered. The machine in its present form is shown in Fig. 1. Its base is a stout piece of mahogany, 21in.

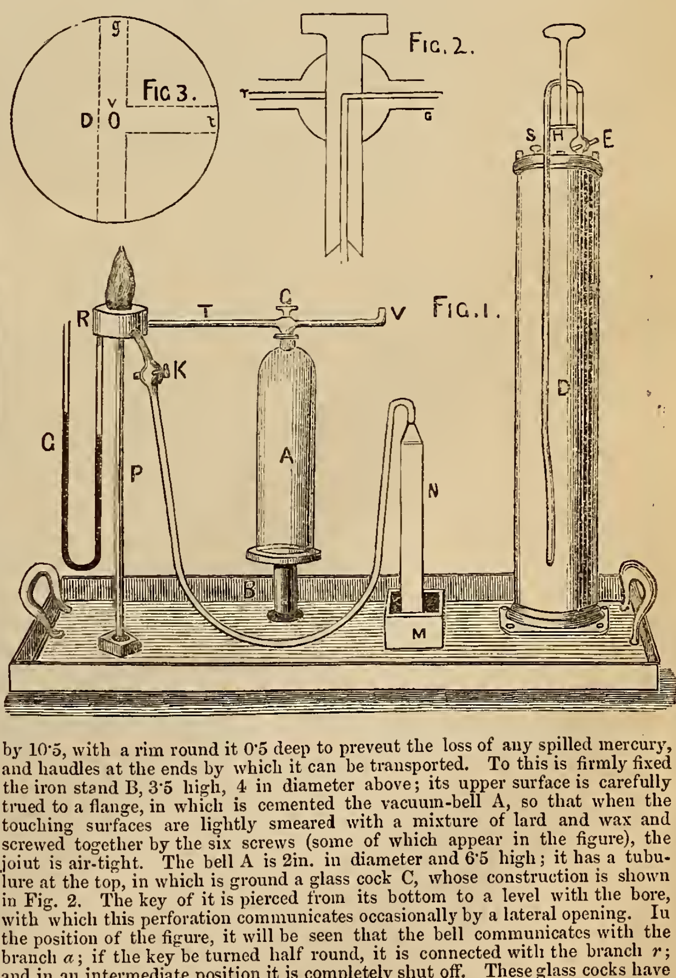


Fig 3. Fig. 2. Fig. 1.

by 10·5, with a rim round it 0·5 deep to prevent the loss of any spilled mercury, and handles at the ends by which it can be transported. To this is firmly fixed the iron stand B, 3·5 high, 4 in diameter above; its upper surface is carefully trued to a flange, in which is cemented the vacuum-bell A, so that when the touching surfaces are lightly smeared with a mixture of lard and wax and screwed together by the six screws (some of which appear in the figure), the joint is air-tight. The bell A is 2in. in diameter and 6·5 high; it has a tubulure at the top, in which is ground a glass cock C, whose construction is shown in Fig. 2. The key of it is pierced from its bottom to a level with the bore, with which this perforation communicates occasionally by a lateral opening. In the position of the figure, it will be seen that the bell communicates with the branch *a*; if the key be turned half round, it is connected with the branch *r*; and in an intermediate position it is completely shut off. These glass cocks have this great advantage over those of metal, that it can always be ascertained if they are air-tight; their transparency permits us to see if the key and shell are in optical contact; and the slightest air-way there is at once detected. They should not be lubricated with oil, which *grips*, and may perhaps find its way

* Have previously received Telford medals.

into the bell and soil its interior. I find the best material to be castor oil with rosin dissolved in it. A hole is drilled down the axis of B, which communicates by a tube (sunk in the wood and therefore not visible in the figure) with the cast iron cylinder D. This is 13in. high and 3·2 in internal diameter; its top and bottom are secured to it air-tight by screws; in it works a plunger of boxwood well varnished 10·4 high, and moving so loosely that mercury may pass it easily. The plunger is wrought by a rod passing through the collar of leather H. In the top of the cylinder is a stopcock E, to which is fixed a tube of vulcanised caoutchouc (varnished with a solution of caoutchouc in benzidine), which is shown hanging down; it has a coupling to connect it with an ordinary air pump. There is also in the top a screw S for admitting air. One end of the bell's cock communicates with the atmosphere, the other with the receiver-plate R. This is of glass 2in. in diameter, 0·75 thick, and is cemented on the top of the iron pillar P. Through it are drilled the passages shown in Fig. 3; in t is ground the glass tube, shown in Fig. 1 by T, the end of which is in contact with the cock, and their junction made air-tight by a tube of Para caoutchouc; in g and k are similarly ground the siphon-gauge G and the glass cock K. These all communicate with the receiver by the passage v, and by removing the tubes can be easily dried or cleaned. The cock K is connected by elastic tube with the catch-jar N, which is supported in a small mercurial trough M.

The operation of this machine as an air pump is as follows:—The receiver being placed on R, open the screw S, press down the plunger nearly to the bottom of the cylinder, remove the key of the bell-cock, and pour through the opening which it leaves as much mercury as will fill the bell to the bore of the cock. In this one 10lbs. are required. Raise the plunger to the top, and the metal will subside from the bell till only 0·3 of an inch remains on the top of B, filling the space left vacant in D by the rising of the plunger. The length of the plunger and the height of B must be adjusted to this condition. Replace the key; turn it to communicate with the atmosphere (which position I call (a)), and depress the plunger. The mercury will rise again in the bell, filling it, and expelling the air from it, till at last a little mercury will appear in the bore of the cock. To prevent this from being splashed about, a bit of bent tube v is ground on the end of the cock, which receives it, and when it has too much is removed and emptied into D through S. Secondly, turn the key to shut off the bell (position (o)); draw up the plunger, close S, open E, and couple it with an air pump, with which exhaust D. This pump may be of the commonest description, for an exhaustion of one or two inches is quite sufficient. The mercury will sink in the bell, leaving above it a Torricellian vacuum. Close E, and turn the key to communicate with the receiver (position (r)); its air or gas will expand into the bell.

These three operations form the cycle of operation, and must be repeated till the required exhaustion be obtained, with one modification of the first one. In it, at the second and all subsequent strokes, the key is to be at (o) and S opened; thus the atmospheric pressure will raise the mercury and do much of the plunger's work; that must then be depressed and the key set at (a); the other two steps are as at first.

When the instrument is to be used as a gas-holder, either the receiver must be in its place, or the opening of R must be closed by a piece of flat glass; the bell must be filled by the plunger, and made, by (r) and by opening k, to communicate with the jar N. The mercury will rise in that to its neck, and sink in A; fill A again, pass gas into N, and, by carefully working the key, draw it into A till that is full. As this gas will be mixed with the air of the vessels and passages, it must be expelled, and A refilled till its purity is certain. If it be noxious, it must be conducted into some absorbent fluid by an elastic tube, slipt on the a end of the cock; which will also convey the gas to any vessel.

If it be required to fill a receiver for experiments in an atmosphere of gas either at common pressure or a less one, it may either be exhausted by an air-pump connected with K, and filled from A, or exhausted by A and filled from N. The former can only be done with gases which have no action on brass.

These operations seem complicated when described with so much detail, but in practice they are very easy, and their result is good. Some precautions, however, are required to insure it. The bottom of the bell-cock and of its key must be ground, so as to leave no shoulder or hollow in which air may be entangled when the bell is filled. Every part of the metal work must be air-tight; this can only be secured by covering, not only its joints, but its whole surface with several coats of varnish-paint—best of white lead. When the first coat is applied, on exhausting the apparatus, every hole or pore is revealed by an opening in the paint (often almost microscopic), which must be filled up as it forms till all is tight. It is almost needless to mention that the whole must be perfectly dry. If the bell be filled a few times with undried air, enough of moisture will adhere to its walls to prevent an exhaustion of more than 0·1 inch. In such a case it must be dried by drawing air into it through sulphuric acid, and this repeatedly. Moisture also occasionally finds its way into a part still more troublesome, into the passage which connects the bell and cylinder; it is probably condensed there when the mercury is colder than the atmosphere. I remove this by connecting the tube of K with a desiccator; setting C to (r), opening K and E, and by working the air-pump drawing a stream of dry air into D, which bubbles up through the mercury in the passage, and at last sweeps away all trace of water and its vapour. In this operation it is necessary to remove a portion of the mercury, as otherwise it would be sucked into the pump; indeed, this mischief might occur in ordinary work by some mistake in the manipulation—for instance, by leaving E open with (a). To prevent the possibility of this, D is connected with the pump by a mercury trap, easily imagined, which intercepts any of that metal that might come over. And lastly, the interior of the bell must be perfectly clean if the highest degree of exhaustion is required. This state is obtained by washing it with strong nitric acid, then with distilled water, and when quite dry wiping it with linen, from which all traces of soap or starch have been removed by boiling it in rain-water. Thus we reduce to a minimum the film of air which adheres to the bell even when filled with mercury, and lessens its vacuum. When all these precautions were taken, I found that with a receiver containing 3·7in., the fifth operation brought the gauge (which had been similarly cleaned and carefully boiled) down to 0·01. The sixth brought it still lower, but my present means of measurement* are not sufficient to determine the precise amount. In this machine the old air pump theorem ought to hold, and by it, with the fraction $\frac{3\cdot7}{1\cdot7}$, I find that the fifth should give 0·007, and the sixth 0·0014; so that the presence of adhering air is still sensible, though very slight. So high a power, however, is not long maintained; for by use, and especially with oxygen, which (probably from the presence of ozone) has a peculiar tendency to dirty mercury, the bell becomes soiled; but it continues to give a vacuum of 0·02, which is quite sufficient for ordinary objects. At common pressure and temperature, the electric discharge through the receiver shows no evidence of the presence of mercurial vapour; but at 0·02 it is otherwise; the discharge is greenish white, and the spectrum shows little except the lines of mercury. If the gauge were detached, perhaps this vapour might be absorbed by gold-leaf.

The apparatus acts well as a mercurial gas-holder, and can deliver 18·5in. Like all other contrivances for confining gaseous matter by mercury, it is liable to have its contents contaminated with air by diffusion between the metal and the vessel which contains it; but I expected that in this arrangement the defect would be little felt. In order that it may take place, the air must pass a distance of 17·2in., of which 14·6 is a tube only 0·125 in diameter, and the rest is in a vertical direction against the pressure of 2·6in. of mercury. A single experiment will show how far this avails. The bell was filled with dry hydrogen, which was found to contain 0·901 of the pure gas; it was left for ten days exposed to considerable changes of temperature, and was then found to have 0·854; it was therefore contaminated at the rate of 0·005 per day. I am not aware of similar measures with ordinary mercurial apparatus; nor is this amount of error very important; but it may, I believe, be corrected by a means long since announced by Professor Daniell which has been strangely neglected. He proposed it to prevent the infiltration of air into barometers. If the liquid metal adhered to the surface which it touches, as water would, this action could not occur; now it wets, if I may use the word, several metals, as copper or silver, but it also dissolves them, and becomes less fluid. Daniell, however, found that it does wet platinum without acting on it in any injurious degree; and advised that a ring of platinum wire should be fused round the tube where it dips into its cistern. On inquiring of his friend and fellow-labourer, Dr. W. A. Miller, I learn that it was completely successful, but was not taken up by the opticians, and passed out of memory. It is obvious that if a bit of platinum tube were cemented in the vertical passage below D, it would effectually bar the diffusion. I do not like to undo the joint there, which is now perfectly tight; but I will certainly, when the opportunity offers, try the experiment.

SCOTTISH SHIPBUILDERS' ASSOCIATION.

ON COMPOSITE SHIPS.

By John Jordan.

Since the canoe dug out of the solid ceased to be adequate for human requirements, skeleton framework of various devices has been employed in the fabrication of floating structures. The most remarkable feature in the latest development of the art of shipbuilding is the return to original ideas of the most primitive times, but with a wonderful increase of power. The latest specimens of the shipbuilder's skill are to be found in those vessels built of steel, of large tonnage, inclosing nearly 150,000 cubic feet of space by a material scarcely thicker, but infinitely stronger, than the skin or bark covering with which our ancestors barely inclosed one thousand times less space. Nor does the parallelism end here; for the slender but strong framework of steel bars bears a striking similarity to the wicker skeletons upon which aforetime the skin coverings were stretched and secured. The lightest possible fabric is thus formed of a strength equal to the requirements of commerce, and a further limitation is thus attained of the weight of material necessary to inclose a given space within the bounds of a floating structure.

The term composite applied to ships can of course only be relative. Strictly speaking, all ships are composite ships, inasmuch as it would be inexpedient, if not impossible, of one material to make all the various parts of so compound a structure as a ship. To select one material for the construction, or one shape of which to make all the various craft used in modern commerce, would be to degrade the science of shipbuilding to the level of the merest quackery. Throughout this paper the term composite will be used to denote those vessels whose skeletons are of iron or steel and the shell or cover of timber; and it is proposed to investigate the character of these elements as applied to such structures.

There are principles in nature which render highly organised forms, in which life and motion are developed, subject to rapid change. The mountains change slowly, and by agencies outside them. The oxidising atmosphere, the degrading torrents of wind and rain, disintegrate and transport their substance to regions where it is caught up by the vegetable forces, and fashioned into forms fleeting and visionary compared with the everlasting hills from which it was detached. Some of these forms flash into life and disappear many times during the period of one

* A micrometer microscope put in the place of the telescope of my theodolite.

generation of mankind. These are of course useless for the purposes of shipbuilding. From this point there are gradations infinite in degree, up to those gigantic forest trees whose periods are measured by many generations of mankind. It is among these are found the materials which the constructive art of the shipbuilder has converted into those floating structures which hitherto have rendered commerce possible.

The characteristics of the most suitable organic forms for shipbuilding purposes are the oily, the resinous, and the acidulous. Of the first, the teak class of woods affords an example; of the second, the hard pine timber; and of the third, the oak may be taken respectively to represent the three classes of which we speak. Each of these classes include many members possessing qualities in common with the others, and varying much in weight, durability, and strength. This variety gives the shipbuilder a command of material of which advantage has been taken.

We may remark here that organic forms change either in growth or decay from within,—the process is invisible during the instant of its operation; while inorganic substances change from without, and the changes are palpable to human observation, and under control. This principle lies at the root of the desire manifested by the shipowning faculty to substitute an inorganic material, iron, for the organic forms, timber, of which until lately all ships were built, and which sometimes defied every effort to arrest their utter dissolution. We are all aware this substitution of metal for timber has given nearly absolute command over change, but the price paid for this command is a high one. Some of the items of this price are, fouling, detention in dock to paint, and extreme compass errors.

Each circle of life demands for its accomplishment the presence in proper quantity of the desired elements. The partial absence of some one element, and the presence in excess of others, modifies, totally changes, or stops altogether the natural course of events. Introduce into the acidulous class of timber a metal, say iron, with a strong affinity for oxygen, and let water have access: we see the metal converted into an inky soluble compound, and the wood into a disorganized mass, no longer timber, but the incoherent dust of the former organism. The intelligence of the shipbuilder is here called into requisition to so arrange his substances that decay may be delayed.

Speaking of the teak, or oily class of woods, some oils exposed to the atmosphere absorb oxygen, and become changed into a thick, slow-changing india rubber-like mass. Others are changed by the same process into a resinous varnish, which is a still slower changing substance. This peculiarity renders oil-bearing timber very durable, preserving from decay the fibres of the timber, which become fixed in the oil changing into varnish. Every person who has worked teak must have noticed the yellow colour which teak presents when newly chipped change into a reddish east. This change is due to the absorption of oxygen by the oil of the wood. Not only are the fibres of the wood preserved, but oxidizable metal bolts driven into such timber are thereby coated by a film of oil, which is converted into varnish by the action of the atmosphere. The durability of teak-built ships iron-fastened is thus easily accounted for; while iron-fastened ships built with acidulous timber are proverbally short-lived. Four years is no uncommon period at which to find iron fastenings in such ships is gone, while in teak ships forty or fifty years is sometimes reached in which the original iron fastenings may be found in such ships.

It would be well to mention here that the coating of an oxidizable metal whose oxide is soluble, with another metal whose oxide is insoluble, has been found of great service. Iron bolts and nails galvanized or coated with a film of zinc are found to be well protected by the oxide of zinc which forms upon and continues to protect the iron beneath it.

The resinous class of woods are intermediate between the oil-bearing and the acidulous. The resin or varnish is already formed, and its hard nature does not form so close a fit over the intruding bolt. The consequence is, that moisture gets in and is decomposed. The oxygen being absorbed by the metal, a rusty circle round the bolt shows that the process of slow combustion is commenced, requiring but time to complete its operations. It is necessary in this class of timber, as well as in porous spongy timber, to use some insoluble saponaceous substance to coat the holes and the bolts. This answers the same purpose as the natural oils of the teak class of woods. What is meant by a saponaceous substance is, the combination of the oxide of a metal, or of calcium (lime), with some fatty or oily substance. All holes and bolts should be coated before driving. I believe by far the best application would be Ransom's gelatinous silicate of soda, into which the bolts might be first dipped, and immediately after dipped in chloride of lime. A coating of silicate of lime is at once formed upon the bolt, capable of resisting the concussion of driving, and impervious to moisture. If some light porous timber, such as dry spruce or pine, were impregnated with silicate of soda, and afterwards with chloride of lime, a ship might be built of which it could be said that she was lighter, stronger, and more durable than any existing floating fabric, and, strength for strength, cheaper; and if such a ship had a steel frame coated with the same material, no limit could be put to the term of such a vessel's existence.

Passing to the consideration of the strength of a composite ship, we may arrive at a conclusion from the consideration of well-known facts in another and kindred art. Flat-sided boilers, judiciously stayed, are found capable of standing from 30lb. to 45lb. pressure per square inch. The sides are not often more than $\frac{3}{8}$ths of an inch thick, if the iron be of best quality. The pressure upon a ship's bottom drawing 30ft. of water, as the *Great Eastern* does when fully laden, is not more than 14lb. per square inch, or about one-third less than many boilers are now carrying under a high temperature. Now, the result of experiments made both by steady pressure and by impact show that a 3in. oak plank is equal in strength to a $\frac{5}{8}$th inch iron plate; while a slightly thinner plank of teak is also equal to the $\frac{5}{8}$th inch plate.

In American ships of large tonnage and draught of water, the outside planks are attached by short treenails and bolts to a timber frame, which is supposed to be capable of sustaining any ordinary strain the ship may be subjected to. The outside plank seldom exceeds $4\frac{1}{2}$in. in thickness, while the topsides are generally about $3\frac{1}{2}$in. In these vessels we have a true case of a tight shell pegged upon a consistent frame, and we know from experience that American ships do their work, and do it well.

The relative strength of iron, teak, elm, and oak, are for tensile strain, 21 tons, 7 tons, and 6 tons respectively for elm and oak. Rejecting oak as an acidulous and not very straight-grained timber for planking, we have two materials, elm and teak, the first of which is cheap, and very suitable for planking below the water line the composite ship, being at once tough and comparatively free from acidulousness. Above the water, teak is the only unprepared timber fit to resist atmospheric changes. It is stronger and more durable than any other description of timber, and is lighter and less easily split than greenheart. Now, a 3in. plank being equal to a $\frac{5}{8}$th inch plate, it has been found that a 4in. plank is nearly equal to a $\frac{7}{8}$th inch plate, and we know that the thickest plates in the *Great Britain*, now twenty years old, are of that dimension; it follows that a ship of any magnitude, if planked with 5in. plank, or at most $5\frac{1}{2}$in., would be practically as strong—in fact, much stronger than necessary. Planks of this thickness allow the bolts to be punched up an inch to receive a plug, so as the nails which fasten the antifouling sheathing on may never penetrate through them. After every removal of such sheathing, a coat of waterproof stuff should be given to fill the holes, and smooth all off before another sheathing is applied. It may here be remarked that ships are subject to severe local concussions, which start the planks and caulking, thus causing leaks more annoying than serious. It has been the practice to edge-bolt several strakes together—viz., keel and garboard strakes and two strakes each sides, three strakes at lower turn at bilges, the bindings, and gunwales, which are the more exposed to local injury of this character. These edge-bolts act as dowels also, and give additional strength to the fabric longitudinally. The shell of a composite ship, when planked with good sound timber, dressed off fair, bolted through holes in the frames to suit the planks, plugged, sheered fair, and planed, is a most beautiful job; and some vessels built lately on the Clyde reflect the highest credit upon their builders and the locality. One or two coats of some waterproof substance should be given after caulking, or paint of a good consistency applied; and the inner surface of the antifouling sheathing should also be painted, to reduce the wear upon the inner surface of the metal, and prevent galvanic action. Barring accident or want of judgment, such a vessel should go four years without the intervention of a shipwright, and then only require docking to renew the sheathing.

The vertical upward pressure upon a ship at rest, loaded—say, for example, a 1,200 ton ship, 200ft. long, 35ft. beam, 23ft. deep,—may be taken at 2,900 tons. Suppose the vertical cross section to be rectangular, there would be a flat-bottomed surface of about 4,500ft., sustaining a pressure of about 9lbs. per square inch. Suppose, further, the load or cargo removed (which balances the upward pressure) from $10\frac{1}{2}$ft. amidships (like an empty coal bunker), but so that the upward pressure is not diminished—this surface, $10\frac{1}{2}$ft. fore and aft by 35ft. wide, would have to sustain a pressure upward of 237 tons. Now, an elm plank 12in. wide by 5in. thick by $10\frac{1}{2}$ft. long will carry a permanent load of 3 tons—there would be thirty-three planks in such a vessel as we are now considering, besides the keel; the planking would therefore bear 99 tons. The keel would be 16 × 16, with a keel plate 21 × $\frac{5}{8}$ths on top, equal to elm keel 20 × 16 without false keel;—$10\frac{1}{2}$ft. of such a keel would support 70 tons, and the garboard strakes 10 tons additional. In a length of $10\frac{1}{2}$ft. there would be eight frames, floors, and reverse frames, 23in. deep by $\frac{5}{8}$ths thick. Each of these will carry 12 tons, or 96 tons for eight floors, frames, and reverse frames. The shell and floors alone of a composite ship are thus capable of sustaining 275 tons, being 38 tons more than the 237 tons of extreme pressure which can by any possibility come upon them. In the bottom of a 1,200 ton ship, there would be five keelsons—say centre-box keelson 18 × 12 × $\frac{5}{8}$in. plates. This box for $10\frac{1}{2}$ft. would sustain 240 tons, and four bilge and assistant keelsons would support, if made of double 6 × 4 × $\frac{5}{8}$

angles, 20 tons, making a total of 280 tons for the strength of the keelsons to resist upward pressure. We arrive, then, at this conclusion—viz., with the weakest form of bottom, viz., a straight one thwartships, and the greatest pressure possible,—a composite ship has more than double the strength necessary to resist upward pressure. When the modifying circumstances of shape are considered (we find rounding the bilges shortens and by so much strengthens the floors; rise of floor also diminishes the upward pressure by the sine of the angle of rise), we have many times more strength over and above what is needed.

Returning to the 237 tons of upward pressure we have eight frames and reverse frames upon each side through which to transmit this pressure to the sides. These 16 frames have a cross section of 128 square inches, which, at 12 tons, the compressive strength of wrought iron, gives 1,516 tons as the power of the frames to transmit 237 tons. It will not be necessary to say that ample margin is left here for rivet holes and defects of construction.

The vertical depth of side amidships of a ship 200ft. by 23ft. by 35ft. would be about 20ft.; and the strength of two such sides, 5in. thick each, of teak, would be 2,000 tons round numbers, using Mr. Barlow's rule, $\frac{2\,S\,a\,d^2}{l} = u$. To this must be added the vertical and horizontal stringer section at the bilges, lower deck, and gunwale, also the side stringers below the hold beams, and the deck ties. This may be taken roughly at 100in. for tensile strength at the gunwale, and 50in. compressive resistance at the bilges, making 2,100 and 600 tons = 2,700 tons, or a total of 4,700 tons, to sustain 2,900 tons of total displacement.

Some eleven years ago an experiment was tried upon one of these vessels built at Liverpool. The blocks and shores were removed from a composite vessel for nearly one half the vessel's length, so that she would not absolutely tip. A jack screw supported the forefoot, and a sheet of paper was placed between the head of the screw and the forefoot, or rather fore end of the keel. Upon the first turn of the lever the sheet of paper was withdrawn, there was so little deflection. Now, in practice, it is scarcely possible such conditions can exist; ships are built to be water borne (and, while water borne and at rest, the weight inside balances the upward pressure outside), or to take level ground, or at all events tolerably level ground; and no provision can be made to resist such enormous momentum as is generated by a ship in motion striking an unyielding object of limited dimensions; if the force is great enough the part struck is destroyed. Ships are not built to batter rocks to pieces. This is true for every description of vessel. We have spoken of 2,900 tons displacement. Now, if the ship we speak of were a parallel structure, it would bear some relation to a beam 200ft. long; but ships are nearly parabolic in shape, so that the ends are comparatively free from strain, except that arising from their own weight. This circumstance reduces the length of the beam under consideration about one third—or, what is the same thing, the weight a beam 200ft. long has to bear—so that 2,900 tons displacement reduced one third becomes less than 2,000 tons, which the timber in the sides of the skins is capable of sustaining. This statement is borne out by the fact that soft-wood ships' sides are just, and barely sufficient to be kept in shape by the vertical strength of their inside and outside planking.

In the soft-wood ships' spoken of, the framing or ribs depend entirely upon the planking of the sides to resist alteration of shape; and well-built specimens of North American ships can be seen in perfect shape after a series of years, during which destruction of much of the original strength has been accomplished.

In the British-built hard-wood ships it is no uncommon thing, as experience has shown, to find the frame substantially worthless, and yet the vessel held together and in perfect shape. I remember digging the after end of a colonial ship's frame out with spades, the planking doing all the work, and perhaps more than ever called upon to do, before the constitution of the frame had departed. Every shipwright can recall similar instances. With respect to composite ships generally, there are, as might be expected, many notions respecting the methods of arranging the material constituting the iron framing. Some prefer vertical frames or ribs connected to longitudinal fastenings, crossing the frames at right angles at tolerably equal distances, bearing some proportion to the vertical strength of the parts crossed, and the respective strains borne by them. These have been supplemented by curved girder stringers upon the sides, extending from the luff of the bow, sweeping down to the upper part of the bilges, and thence upwards to the turn of the quarter. These, when crossed by the lower and upper deck vertical stringers, are inverted arches, having literally two strings to their bow. The keelsons, too, have assumed the inverted arch form, rising over the dead wood past the lower to the upper deck stringer: these have also the double string to the bow, being secured to the stem and stern plates, and to the upper and lower deck stringers. Lateral strength is got by breadth of stringer plate upon the deck beams, which should always be in some proportion to the length of the vessel. This remark also applies to centre keelsons. Bilge stringers naturally assume the arched form when carried all fore and aft, as should be invariably the case, and joined across the ends; they resist alteration of shape with a force compounded of their section of metal and curved shape. They thus form breast-hooks, and should be equidistant from the hold beam stringer to the keel.

Lloyd's registry insist upon a diagonal system of lacing bars, which it is difficult to discover the use of. Many people suppose some magical influence to attach to diagonal arrangements. They are simply useless, when the object is attained by other methods. The office of diagonal arrangements is simply to save material by joining a rigid top to rigid bottom; one being in a state of compression and the other in a state of tension. But in such a structure as a composite ship, where the material is so lavishly disposed, strong, and ample, and where the vertical bars do this duty so admirably, it seems ridiculous to introduce additional weight of material. A plan has lately been proposed to place the ribs longitudinally fore and aft. Now, except some provision of vertical or diagonal system is introduced, the vertical pressure cannot be transmitted from the bottom to the sides, or *viçe versa*, except through the timber shell. This is a vice to be guarded against.

A number of ships have lately been built upon a mixed system—viz., with wood bottoms to the turn of the bilge; keel, keelsons, floors, and ceiling, all wood. The special vice of this form of construction is more fatal than the last, because the junction of two materials of unequal capacity to transmit strain must result in the destruction of one or both of them. Now, this junction taking place in the bilges of vertically framed ships, which are the weakest and most liable to injury in the wood-bottomed vessel, owing to the nature of the material, appears to be a method founded upon no practical scientific data. The object of introducing timber in the framing of the bottom of a composite ship seems to have been to *protect, by raising* the iron part out of liquid contact with the water generally found in more or less abundance in the bottom of ships. A moment's consideration would have shown that, in sailing ships, especially, there lies more water in the bilges than in any other place, for the simple reason that the vessel is always more or less inclined by the force which propels her. The frame of a composite ship should be *self-consistent*, and *derive no important part of its strength from the timber sheet.* One other circumstance condemns the plan of wood bottoms. Under the butts of a composite ship's planks a plate is rivetted joining the two frames; upon this plate the butt is cut so that a firm grip is got of the two ends of the abutting planks, which are further supported by the butt plate joining the adjacent frame. The whole of this advantage is lost in the wood bottom, and started butts are just as liable to the wood bottomed composite as to the entire wood framed vessel.

A remark may here be made respecting decks. If the butts of deck planks were made upon plates joining the beams, or even rivetted to them, they would be much stronger and better than the present imperfect fastening in the bare end of the plank.

Some builders make the centre keelson of timber, fitted upon wood chocks jammed in between the floors, the whole bolted through. Reference to the strength of a box keelson of iron 18 × 12 × $\frac{5}{8}$ths, and of an elm keel 20 × 16, will settle such a question: 210 tons against 70 tons is a large balance. Another modification has been adopted with some success, in which a wood rib is attached to the iron ribs, for the purpose of getting the shell pegged on to it by treenails or yellow metal bolts. The keel plate is also dispensed with. There seems to be no reason why so much pains should be taken to produce a less perfect structure; for certainly the element of strength is forgotten in a desire to escape what is so easily prevented or remedied when it occurs. With the ceiling made to lift, oxidation is easily prevented, and if bolts oxidize they can be driven out and replaced. Some vessels have been built leaving out the keel plate: now, the keel scarfs are certainly weak places in a wood ship, and, like the plank butts, require covering. The frames also require some attachment which shall be homogeneous and continuous. This seems a sufficient argument for the retention of the keel plate.

The use of asphalt—true asphalt, not the coal tar rubbish substituted for it—or good hydraulic cement, would obviate all objections upon the score of oxidation of the iron frame. A vessel, the *Tubal Cain*, of 800 tons, was recently wormed in the Eastern seas; and after stripping off the plank, although she was not protected in any way, and ten years old, none of the frame required removal. If either true asphalt or Portland cement had been used, the same result could be attained as in the little *Excelsior*, built in 1849-50, which has carried sugar, and worn out I cannot say how many iron vessels in the same trade, and is, according to her owner's report, as good as new. This vessel has been kept constantly coppered, has no wood sheathing or diagonal arrangements, is iron bolted, and continues to do work of a most trying description.

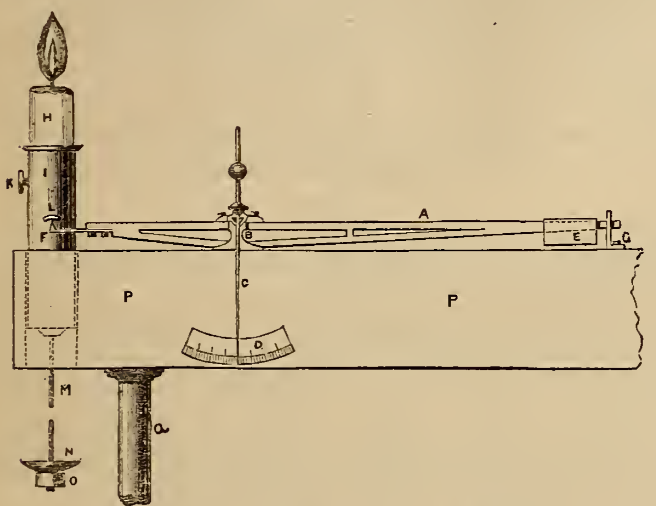
Some vessels have been built with what are called false floors, or more correctly chocks, tapering from an inch at the lower turn of the bilge to six or nine inches at the garboard strakes. These chocks allow a good watercourse to the pumps, and keep any water below the frame. Some builders punch the holes in the frames through which the bolts pass to secure the wood planks before the frames are put up: this is a bad job, as it is

scarcely possible to lay down each plank so accurately as to secure that the holes shall be properly spaced in the planks. The planks should be lined off after the ship is in frame, and the holes bored or punched to suit them.

I have endeavoured to give an account of my impressions respecting composite ships during the last fifteen years—a class of vessel much sneered at by the learned in shipbuilding; and I would record my intense gratification at the production of such excellent specimens (in this most celebrated and scientific ship-producing neighbourhood) of a plan laughed at immoderately when first proposed.

APPARATUS FOR WEIGHING THE PHOTOMETRIC STANDARD CANDLE.

We are glad to notice that Mr. T. W. Keates, F.C.S., has succeeded in producing a very useful, efficient, and much needed arrangement of apparatus for weighing the Photometric Standard Candle, which is illustrated by the following wood cut:—



This apparatus has been designed by Mr. Keates especially to obviate the inconvenience, and in some measure the difficulty of weighing the standard candle in experiments with Bunsen's photometer, which must have been experienced by all who have had occasion to employ that instrument in estimating the illuminative power of coal gas. During many years of laboratory practice Mr. Keates has resorted to various contrivances to obviate the difficulties which presented themselves in obtaining a fair weighing of the candle in the exact condition in which it is used as a photometrical standard of light; none, however, of these contrivances, Mr. Keates states, proved quite satisfactory until he devised the balance arrangement now ilustrated and described.

The value of any means by which regular combustion of the candle in a photometrical experiment can be secured is scarcely to be overrated. This is the element most easily disturbed in such experiments, and it is also that which is of the greatest relative importance, inasmuch as the candle is the standard of reference, and any irregularity in the manner of its burning necessarily affects the final results to a serious extent, especially when as is often the practice, the experiment is only continued for a few minutes. Under all circumstances, however, it is essential that the burning of the candle should be rendered as regular as possible, and that the candle should be undisturbed and its burning uninterrupted after it has been weighed. These conditions cannot be fulfilled if the candle has to be lighted after weighing, nor if it has to be transferred whilst burning from the balance to the photometer; but it is believed that they can be perfectly satisfied by the use of the apparatus now introduced to the notice of gas experimentors.

This apparatus consists in a particular arrangement of balance adapted to the beam of Bunsen's photometer, at the end which supports the candle, and it is so contrived that it can be applied to any photometer of this construction. By reference to the drawing, it will be perceived that the candle, at the moment of weighing takes the situation which it occupies during the photometrical experiment, and that the act of weighing is performed in such a manner that it does not influence in the slightest way the state of the flame; indeed, after the candle has reached its regular rate of combustion, it is not touched until the experiment including the second weighing of the candle is completed.

The balance employed in this apparatus, as it is shown in the drawing, is constructed with arms (A A) of unequal length—the distal arm, or that furthest from the candle, being twice as long as the other; the only object of this is the reduction of the weight of the counterpoise E which which can thus be made of half the weight that would be required if the arms of the balance were of equal length. This not only facilitates the use of the instrument, but it diminishes the total weight upon the centre knife-edges.

In the drawing, the balance is shown in the position which it, and consequently the candle, would occupy during the photometrical experiment, with the trifling exception that the candle is one-tenth of an inch too low, as in the practical form of the instrument there is a contrivance for lifting the candle-holder off the knife-edges so soon as the weight of the candle is ascertained; this is done by a rack and pinion arrangement which raises the candle-holder one-tenth of an inch, and holds it firmly whilst the power of the light is being estimated. Afterwards, the candler-holder is lowered again upon the knife-edges for the second weighing.*

The manner of using this instrument is so simple as scarcely to require any explanation. A few minutes before commencing the photometrical experiment, the candle being raised to the proper height in the candle-holder and fixed by the small screw, K should be lighted and allowed to burn quietly until the flame has arrived at what may be termed, with reference to the photometer, its normal condition; this being so, the shifting counterpoise must be gently pushed along the balance-beam a little towards the centre, so as to allow the candle to carry down its end of the balance. Attention must now be given to the instrument for a short time. As the sperm is consumed and the candle becomes lighter, equilibrium will be restored to the balance, and the candle will very gently and gradually rise, so that the index C of the balance will be brought to zero of the scale D. At that moment the exact time by the clock must be observed, as this is the starting-point of the experiment so far as the consumption of sperm is concerned. The candle-holder must next be raised very gently off the knife-edges, when the photometrical estimations can be carried on as long as may be required. When these are terminated, it only remains to make the second weighing of the candle. For this purpose the candle is extinguished carefully, and as quickly as possible, and the time which has elapsed between the moment at which the index of the balance pointed at zero of the scale and that at which the candle was extinguished, noted. The candle-holder is now again lowered upon the knife-edges of the balance, and weights are placed in the small scale-pan N hanging below the candle-holder until the balance once more turns. These weights represent exactly the quantity of sperm consumed during the burning of the candle, the hour's consumption being, of course, a question of proportion. Referring to our woodcut, B is the support for centre knife-edges; C, Index, with scale D; F, Knife-edge at extremity; G, Rest for balance during the experiment; H, Candle; I, Case for candle; L, Steel projections, by which the candle-case is suspended on knife-edges; M, Brass rod, to which is attached the small scale-pan, N, and balance-weight O; P P, Portion of the end of the photometer-beam; Q, Support to ditto.

Mr. Keates, as far as his experience of this little apparatus has extended, finds that it entirely does away with the troublesome and unsatisfactory weighing of the candle by the usual method; and if it is arranged, as it can very easily be, with a movable cover to fix over it, candle nor balance need ever be removed from the photometer, and the whole instrument is then always most conveniently ready for use.

We may add that the apparatus we illustrate is manufactured by Mr. Sugg, of Marsham-street, Westminster.

* I have intentionally omitted to show this contrivance in my drawing, as I found some little difficulty in sketching it so that its mode of action could be made quite clear, but I shall be happy to show the apparatus itself to any person interested in the matter.

Shipbuilding on the Clyde.—"The works of Messrs. Randolph, Elder, and Co., Govan and Centre-street, Glasgow." Under the above head we find, in a recent issue of the *Glasgow Daily Mail*, an excellent descriptive sketch of the rise and progress of the above firm, who have acquired a well-earned reputation as general engineers, during the last thirty years; and though it is only some three or four years since the firm extended its business operations, into iron shipbuilding, the following list of ships lately built or now building by the company, will give our readers an idea of the rapid advance made by them in this new department of their operations. They have at present in the river, on the stocks, and more or less advanced, or having their keels laid, altogether thirteen steam vessels, varying from upwards of 2,000 tons to 200 tons burthen. The following list will serve to show what those ships are:—

	Tons.	Total Tons.	Total H.P.
3 Steamers for the Pacific Mail, each	2,048	6,144	1,200
1 „ far advanced (the *Payta*)	1,800	1,800	400
2 Paddle Steamers (launched)	850	1,700	400
3 „ keels laid	850	1,700	400
2 Screw Steamers, Indian Trade, composite (wood and iron)	1,050	1,100	400
1 Screw Steamer, Indian Trade, composite (wood and iron)	900	900	200
1 Steam Packet for Japan	200	200	30
		13,544	3,030

One floating dock, 300ft. long, 100ft. broad, 37ft. deep.

Perhaps the specialty in connection with the above firm with which our readers are most familiar is the system of double cylinder expansion engines, introduced by Messrs. Randolph, Elder, and Co., and which, fitted on board the vessels of the Pacific Royal Mail Company, have been found to work so satisfactorily and economically as to justify our making frequent allusion to the subject; and the log of one of these, the *Chile*, will be found in another page of our present issue.

Messrs. Russell's New School-room and Concert Hall, Wednesbury.—Among the firms in South Staffordshire most prominent for taking an interest in the pleasures and welfare of its servants is that of Messrs. James Russell and Sons, of the Crown Tube Works, Wednesbury. The present proprietor of this establishment has long supported a library and reading-room, a school, three bands—composed entirely of men and boys employed on the works—a cricket club, and other organisations calculated to exercise a beneficial influence upon the 400 or 500 persons employed in their works. Lately Mr. John James Russell has completed a new concert-room and lecture hall, two school-rooms, and a dining-hall for the use of his *employés*. The new buildings—which have been put up from designs by, and under the superintendence of, Mr. B. L. Brown, Mr. Russell's manager—span the principal entrance to the works from the High Bullen, and extend for a considerable distance on each side of it; and the appearance of that part of the town has been materially improved by the lofty and imposing erection which now surmounts and flanks the entrance gates, completely shutting from view the numerous tall chimneys which spring from various parts of the four acres of ground covered by the works behind. Passing through the entrance gates, and turning into a doorway on the right, we enter a lofty room, 30ft. long by 22ft. wide, designed to be used for the present, for the joint purposes of the boys' school-room, the library, and the reading-room. Here, under the tuition of a competent master, the juveniles employed on the establishment will have an opportunity of acquiring, free of cost, the elements of a sound useful English education; and judging from the mechanical diagrams on the walls of the old school-room, their studies will take a bend calculated to be of the utmost service to them in the position of life in which they are placed. The library contains about 1,000 volumes of standard works, and the reading-room table is abundantly supplied with daily and weekly newspapers and magazines, selected like the books, by the workmen themselves, subject to the sanction of the proprietor. Adjoining this room is another 12ft. square, set apart as a school-room for adults; and adjoining this a third room, measuring 16ft. by 14ft. fitted up as a dining-room for the convenience of such of the workpeople as cannot take their meals at home. Above the floor, but communicating with it by a spacious staircase, is the principal apartment of the series—the lecture-hall and concert-room. This is 60ft. long by 34ft. wide. The roof is supported by four iron girders, cased with wood; and the ceiling, which rises towards the centre from the back and front of the room, is divided into panels, filled with appropriate devices, and coloured in harmony with the other parts of the hall. On one side is placed a commodious musicians' gallery, and the numerous windows which pierce the front and back walls of the room admit a flood of light by day, while four light, airy gas chandeliers, which hang from the ceiling, testify to the ample provision made for illuminating the place by night. Fixed seats are placed against the four walls, and portable ones are provided together with a moveable platform, for use when the room is required for the purposes of a lecture or concert. In this room it is purposed that at frequent intervals, perhaps weekly, lectures, concerts, or social re-unions of some kind or other shall take place, to all of which the female relatives, and in some instances the younger members of the families of the workpeople will be admitted; but in all cases free. All the rooms are heated with hot-water pipes, so arranged that the temperature of any one can be regulated without interfering with the others; and the building is constructed with a view to the opening at no distant time of additional chambers on the left hand side of the entrance gates. The workmen had a trip to Matlock on the 15th ult. At six o'clock in the morning the men and boys mustered at the works, and accompanied by two of their bands, marched to the London and North-Western Railway Station, where they were joined by their relatives and friends, and altogether a party of nearly 900 persons was made up. The excursion, which so far as the North-Western Company was concerned, was superintended and attended by Mr. Street, of the Wednesbury Station, reached Matlock about ten o'clock, and the excursionists, after marching into the town headed by the bands, dispersed. The weather was all that could be desired, and nothing occurred during the day to mar the pleasures of the party. The return train reached Wednesbury about ten o'clock at night. Connected with the works is a provident club, which provides liberally for those who may need assistance from its funds, and the remainder is divided among the members year by year. Were there more such employers we should most certainly hear far less than we now do of strikes and lock-outs.—*Birmingham Daily Post.*

REVIEWS AND NOTICES OF NEW BOOKS.

A Series of Metric Tables, in which the British Standard Measures and Weights are compared with those of the Metric system at present in use on the Continent. By Charles Hutton Dowling, Civil Engineer. London: Lockwood and Co. 1864.

Mr. Dowling has done "good service to the state" by the timely production of the series of tables now published.

The want of such a book has been greatly felt by those who have to transact business involving calculations and measurements in foreign standards, or the translation or conversion of foreign into English, or English into foreign quantities.

The series of tables is perfect, and as in each case the conversions are given—metric to British and British to metric—for length, superficies, solidity, capacity, and weight, no difficulty need be experienced in their application. Besides these, there is a series of miscellaneous tables, such, for instance, as the relation of pounds per square inch to kilograms, to square centimetre, tons per square inch to metrical quintals per square centimetre, and comparison of the scales of Fahrenheit, the Centigrade, and Reaumur's thermometers, and comparison of the British and metric barometers.

Supplément à l'Art Naval à l'Exposition Universelle de 1862, *accompagné de onze Planches Gravés.* Par M. Le Contre Amiral Paris. Paris: Arthur Bertrand, 21, Rue Hauteville.

Admiral Paris, who has done so much for the advancement of knowledge in steam amongst naval men in France, has added to the admirable work published by him a few months ago—"L'Art Naval á l'Exposition Universelle de 1862," and shortly noticed in The Artizan of October, 1863—a supplement, bringing the history of naval progress and the actual state of the navy down to the present time; and treating the subjects as he does from an advanced point of view, and by the light of his superior intelligence, Admiral Paris's work is now the most complete which has been written on this subject in any language.

The present supplement describes and illustrates the turret-ship of Captain Cole, the American turret-ships, Mr. Reed's partially plated ships, the admirable designs of Captain Symonds and the late Richard Roberts, and other armour-plated and turreted ships, and he describes the various mechanical apparatus for manœuvring guns. There are eleven folding plates, illustrating the various subjects with the utmost accuracy and detail.

We are glad to perceive by the addition made to the Admiral's titles upon the cover and title-page that that gallant officer now holds the important post of Directeur-Général du Dépôt des Cartes, et Plans de la Marine, Membre de l'Institut, which we presume is a position similar to that held by the late Admiral Washington—the Hydrographer Royal.

Essays on Sugar, and General Treatise on Sugar Refining, as Practised on the Clyde, with References, Illustrations, Notes, &c. By Robert Niccol, Practical Sugar Refiner, Greenock. Greenock: A. Mackenzie and Co. 1864.

Mr. Nicol has performed in an admirable manner the task undertaken by him. Such a work was much required, if we may judge by the frequent inquiries made of us by correspondents. Besides an admirable essay on the article sugar, its origin, and sources, the different descriptions of sugars manufactured, and the processes employed are clearly given. To the various processes of sugar refining

considerable space is allotted, and the preparation of charcoal and its washing and re-charring are interestingly detailed. These valuable treaties are supplemented by some interesting statistics of sugar and molasses, and the work is admirably illustrated with twenty-five plates.

BOOKS RECEIVED.

"Argument in Opposition to the Grant of an Extension of the Letters Patent of Anson Attwood, for Improvements in Stoves. Decision of Commissioner of Patents." By H. HOWSON. Philadelphia: Ringwalt and Brown, 111 and 113, South Fourth-street. 1864.

"Mr. Whitworth and Sir J. Emerson Tennent." From *Frazer's Magazine*. London: James Madden, 3, Leadenhall-street. 1864.

NOTICES TO CORRESPONDENTS.

A JOURNEYMAN FITTER.—We have, since our issue of last month, perused the anonymous letter signed "A Journeyman Fitter," and regret to find that, from the nature of its contents, we consider it both in its matter and manner wholly unfit for the columns of any scientific journal, or for any respectable journal at all; its appearance in THE ARTIZAN is, therefore, under these circumstances, quite out of the question.

D. C. D. (Sydney).—Thanks for the information respecting railway matters in your colony. The subject is interesting to us. The papers having only just been received, we are unable to peruse them attentively, in time to use them for this month. We shall always be glad to hear from you.

A STUDENT IN THE DARK.—We cannot assume any responsibility as to papers reproduced from other publications. The formula in Molesworth is correct, and can be relied upon.

H. S. (Copenhagen).—Your letters to hand just as we are going to press. The deductions, page 54, certainly clash with rule XIV.; the contradiction is evident. We could not see what you meant in your first letter, the editions being different; ours is of 1861. We are precluded from going into the matter now, but will reply more fully in our next number.

R. E. (1.)—Most tables on the properties of saturated steam take no notice of steam "atmosphere being excluded," because the data relating to the latter can readily be obtained from those "including the atmosphere" by a simple arithmetical operation. Thus *e. g.* in that table, page 203 of THE ARTIZAN, 1861, you will obtain the quotients of the two last columns by deducting respectively 14·706lbs., and 29·922in. of mercury from the quotients in the two first columns. You will find one of the most complete tables, containing two columns, "atmosphere excluded," in Mystrom's "Pocket Book of Mechanics and Engineering" (Philadelphia, U. S.: Lippincott. London: Trübuer). In Professor Zeuner's table, which we published in THE ARTIZAN, June 1, 1864, the above arithmetical operation cannot be dispensed with, but this table is one of the most reliable extant.

Example:—46lbs. (atm. incl.) — 14·706 = 31·294 (or 31·3) lbs. atm. excl. 93·633ins. of mercury (atm. incl.) — 29·922 = 63·711ins. of mercury (atm. excl.)

(2.) The following is the reply to your query as to the figures used by the Admiralty to denote the force of the wind:—

FIGURES TO DENOTE THE FORCE OF THE WIND.

0. Denotes Calm.		
1. Light Air	just sufficient to give	Steerage way.
2. Light Breeze......	with which a well-conditioned man-of-war under all sail and clean full would go in smooth water, from	1 to 2 knots.
3. Gentle Breeze ...		3 to 4 knots.
4. Moderate Breeze		5 to 6 knots.
5. Fresh Breeze......	in which the same ship could just carry close hauled	Royals, &c.
6. Strong breeze ...		Single reefs and top-gallant sails.
7. Moderate Gale ...		Double-reefs, jib, &c.
8. Fresh Gale.........		Triple-reefs, courses, &c.
9. Strong gale		Close-reefs, & courses.
10. Whole Gale	with which she could only bear	Close-reefed main top-sail & reefed fore-sail
11. Storm	with which she would be reduced to	Storm staysails
12. Hurricane	to which she could show	No canvas

If the above mode of expression were adopted, the state of the wind, as well as its direction, might be regularly marked, every hour, in a narrow column on the log-board.

J. L. W. (India).—Your communication to hand just as we are going to press. We will look carefully into the subject, and if we are satisfied as to any features of merit which the plan may possess, we will refer to it in a future issue.

THAMES EMBANKMENT.—The foundation-stone was laid in front of Whitehall-stairs on Wednesday, the 20th ult., by Mr. Thwaites, Chairman of the Metropolitan Board of Works.

RECENT LEGAL DECISIONS

AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

UNDER this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

GWYNNE *v.* THE METROPOLITAN BOARD OF WORKS.—At the Sheriffs' Court, Red Lion-square, this case recently occupied the court for five days. It was the first contested claim. Mr. Lloyd and Mr. Horace Lloyd were for the claimant; and Mr. Lush, Q.C., Mr. Karslake, Q.C., and Mr. Raymond represented the Board of Works. The claim exceeded £30,000, and the principal question was whether Mr. Gwynne, who is an hydraulic and mechanical engineer at the bottom of Essex-street, by the Temple-pier, was entitled to compensation for being deprived of the water of the Thames, which was necessary to carry on his works. Last year his net profits exceeded £10,000. He had taken new premises at Battersea, for which he paid £7,000. The Board of Works did not require the premises for the embankment, and a roadway was now being formed, and which would, it was stated, be much better for the claimant. On his behalf it was, however urged that waterside premises were essential to him, to enable him to test the pumps made for foreign Governments. On both sides numerous witnesses were called. The design of the embankment was exhibited in court, and some of the witnesses were of opinion that property in the neighbourhood would be increased in value by the improvements in contemplation. On the part of Mr. Gwynne, a substantial compensation was claimed, and the several items were placed before the jury. Mr. Lush, Q.C., complained of the "monstrous" claim which he said had been made, and called witnesses to disprove some of the allegations advanced. It was impossible to exaggerate the importance to the public of the case now under consideration. The compensation would come out of the public money in the shape of rates. Mr. Lloyd admitted the importance of the case, and complained of the conduct pursued by those in authority, which had been shown in the matter. Mr. C. Pollock, the assessor, summed up the evidence extending over the several days, and laid down the law on the subject. The claimant was entitled to full and fair compensation. The jury, after a consultation of an hour and a half, returned into court, giving a verdict for £14,000.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

GUN-COTTON AND GUNPOWDER.—In an article on gun-cotton, in the *Quarterly Journal of Science*, Mr. Scott Russell says:—1. Is gun-cotton stronger than gunpowder? The answer to this is—Yes; six-fold stronger. By this we mean that if we take a given weight of gun-cotton, say 4ozs., if we bore a hole 1½in. in diameter and 3ft. deep, into hard rock or slate, in a quarry, and put 4ozs. of gun-cotton in it, it will occupy about 1ft. of its length, and the aperture being closed in the usual manner, and a match-line led from the charge to the proper distance from which to fire it; and if we next take 24ozs. of best gunpowder, bore a similar hole, and charge it similarly with gunpowder, and close it in the same way, it has been found that, on these being exploded, the 4ozs. of gun-cotton have produced greater effect, in separating the rock into pieces, than the 24ozs. of gunpowder. The answer is, therefore, that in disruptive explosion the strength of gun-cotton is six-fold that of good gunpowder.

THE ROBERTSFORS IRON WORKS COMPANY, with a capital of £300,000, in shares of £20 each, has been formed for the purchase of the estates of Robertsfors and Fredriksfors, comprising 150,000 acres of freehold and Crown land, with forests, ironworks, and shipbuilding yards. The property is in Sweden, five miles from the harbour of Sikea, in the Gulf of Bothnia. It is estimated that charcoal bar-iron produced on the estate can be delivered in England at £7 16*s.* per ton, and is saleable at £12 10*s.* to £13. Arrangements will be made for carrying on the manufacture of Bessemer steel, from which large profits are expected. The purchase-money will be about £70,000, the vendors agreeing to accept £50,000 for the estates, and that the stock in trade and iron in store shall be taken at a valuation, which will be about £20,000 more. The company will be incorporated with limited liability.

NEW STAMPING MILL.—This is an invention of Mr. Zenas Wheeler, of San Francisco and relates, first, to a certain means employed for taking the powder or dust from the mortar-chamber, and conveying it to the deposit-chamber, the said means consisting of a blast, generated by a fan or an equivalent device, arranged in connection with a blast-spout, in such a manner that the dust will be taken from the mortar-chamber and conveyed to the deposit-chamber, and the same blast made to act continuously, so as to avoid the admission of fresh external air and the consequent mixing of dirt and other

light impurities held in suspension in the external air with the quartz-powder of dust. The invention relates, second, to the employment of a valve, arranged in connection with the mortar-chamber and blast-spout in such a manner that, by regulating or adjusting the valve, the quartz may be reduced to a greater or less degree of fineness. The invention relates, third, to an improved mode of securing the dies in the bed of the mortar, whereby the said dies are firmly held in position, and very readily adjusted in the mortar-bed and detached therefrom. The invention relates, fourth, to an improvement in the construction of the frame of the mortar, whereby the frame is rendered extremely durable, and well calculated to resist the jars and concussions caused by the stampers in the prosecution of their work.

The Raschette Blast-Furnace.—This new blast-furnace invented by Wladimir Raschette, of St. Petersburg, consists first in a blast furnace, the hearth of which, when bisected by a horizontal plane, presents a narrow, long, rectangle, the two short sides of which are to be used as working sides, and its two long sides for two or more rows of tuyeres, and whose long and short sides increase gradually from the hearth up to a point near the throat, in such a manner that a perfectly steady and gradual descent of the charges from the throat to the hearth is effected, and the ore, fuel, and fluxes (as charged in horizontal layers) preserve the same relative position towards each other while descending from the throat to the hearth of the furnace; and, furthermore, the reduction of the ore can be effected in less time and with less fuel than it can in a furnace of the ordinary construction. It consists, further, in the employment, in combination with a long rectangular hearth, of a double row of tuyeres, each tuyere being placed so as to be between two of the opposite sides, in such a manner that a smelting and oxidising zone of uniform temperature and little vertical depth is obtained throughout the entire length of the furnace, and the process of reducing the ore is effected with less fuel and in less time than in furnaces having the tuyeres arranged in the ordinary manner. It consists, further, in the arrangement of one or more fire-places, and fire-flues under the bottom and through the walls of the furnace, in such a manner that a uniform and quick heating of the external walls of the furnace during the erection of the same, and particularly previous to lighting the charge in its interior, can be effected and thereby the successful working of the furnace is rendered practicable, and its durability considerably increased. It consists, finally, in the employment of slotted air-chambers in place of, or in combination with, the tuyeres, in such a manner that the cost of mechanism used for introducing the blast into the furnace is considerably reduced, without diminishing or impairing the effect.

Amber.—This is a substance on which a great deal has been written. It has generally been classed among minerals, although avowedly originating from the vegetable kingdom. Nothing as yet has afforded a clue to the plant that may have produced it; nor has any plausible conjecture been formed from the flowers and insects sometimes imbedded in its mass. Its peculiarly resinous nature seems to point to some *Hymenæa* or to the *Binu Dammara* as the parent plant, but there is no perfect identity between the produce of these genera and amber. Nor is it certain that all kinds of amber proceed from the same source; for its aspect often varies considerably according to the beds in which it is found; which circumstance has led many naturalists to the belief that there are several amber-producing plants. In a paper addressed to the Academy of Sciences by M. Baudrimont, the composition of this anomalous subject is examined. Recluz had already shown that white and opaque amber contains more succinic acid than the perfectly transparent yellow sort; Drapiez had analysed it, and found it to contain carbon, hydrogen, oxygen, and a small portion of ashes, consisting of lime, alumina, and silica. M. Baudrimont, however, shows that it contains another element not hitherto mentioned, sulphur. If a few fragments of amber be subjected in a test-tube to a heat of distillation, and paper impregnated with acetate of lead be immersed into the white fumes evolved, it immediately turns black, thus unmistakably denoting the presence of a sulphuretted compound. The proportion of sulphur contained in amber is not, however, very considerable, since our author fixes it at somewhat less than one-half per cent. But under what form does it exist therein? It is contained in the essential oil, or in the two soluble resins, or in the insoluble bitumen contained in the amber? M. Baudrimont does not tell us, but states that most certainly it is combined with organic matter, because it is evolved under the form of hydrosulphuric acid.

Royal Naval Reserve.—The return for the first quarter of 1864 shows a list of 15,949 volunteers; 15,473 of them had undergone drill; 7,727 were engaged in the coasting trade at home; 5,401 were absent on leave for short voyages, and expected home within periods varying from a fortnight to six months; 1,834 were absent on leave for long voyages, but expected home within a year; the remaining 987 had been either left abroad on account of sickness, or discharged, or deserted.

Our Twelve Chief Ports.—The exports of British and Irish produce and manufactures from the twelve principal ports to places beyond the seas were of the value of £106,962,555 in 1862, and £130,166,569 in 1863—namely, from London £31,523,812 in 1862, and £36,211,510 in 1863; from Liverpool £50,297,135 in 1862, and £65,154,232 in 1863; from Hull £11,916,375 in 1862, and £13,556,254 in 1863; from Bristol £298,260 in 1862, and £341,674 in 1863; from Newcastle £1,968,118 in 1862, and £1,894,281 in 1863; from Southampton £3,379,503 in 1862, and £4,071,991 in 1863; from Leith £1,298,099 in 1862, and £1,552,899 in 1863; from Glasgow £5,776,003 in 1862, and £6,770,368 in 1863; from Greenock £320,225 in 1862, and £455,021 in 1863; from Dublin £48,777 in 1862, and £38,196 in 1863; from Cork £132,130 in 1862, and £108,102 in 1863; and from Belfast £4,118 in 1862, and £12,041 in 1863. The total tonnage entered inwards and cleared outwards from these twelve ports was 17,531,396 tons in 1862, and 17,705,408 in 1863, namely, London 5,855,605 in 1862, and 6,032,340 in 1863; Liverpool 5,269,314 in 1862, and 5,302,123 in 1863; Hull 1,279,943 in 1862, and 1,315,202 in 1863; Bristol 353,889 in 1862, and 327,789 in 1863; Newcastle 2,272,797 in 1862, and 2,268,432 in 1863; Southampton 712,898 in 1862, and 700,182 in 1863; Leith 414,803 in 1862, and 470,566 in 1863; Glasgow 564,947 in 1862, and 505,431 in 1863; Greenock 260,067 in 1862, and 307,041 in 1863; Dublin 266,671 in 1862, and 208,250 in 1863; Cork 151,831 in 1862, and 144,325 in 1863; and Belfast 128,631 in 1862, and 123,727 in 1863.

Bills Passed.—Since our last, the Royal assent, by commission, has been given to the following bills:—Countess of Elgin and Kincardine's Annuity, Fish Tiends (Scotland), Vacating of Seats (House of Commons), Banking Copartnerships, Beerhouses (Ireland), Chimney-sweepers Regulation, Chief Rents (Ireland), Army Prize (Shares of Deceased), and thirty-four private bills. Union Assessment Committee Act Amendment Bill, the Coventry Free Grammar School Bill, the Superannuation (Union Officers) Bill, the Government Annuities, &c., Bill, the Greek Loan Bill, the Settled Estates Act Amendment Bill, the Life Annuities and Life Assurances Bill, and several private bills. The Inland Revenue (Stamp Duties) Bill, the Valuation of Rateable Property (Ireland) Bill, the Penal Servitude Acts Amendment Bill, the India-office Bill, the Summary Procedure (Scotland) Bill, the Ecclesiastical Courts and Registries (Ireland) Bill, the Factory Acts Extension Bill, the Indemnity Bill, the Indian Stocks Transfer Act Amendment Bill, the Street Music Bill, the Lunacy (Scotland) Bill, the Admiralty Lands and Works Bill, the Pilotage Order Confirmation Bill, the Public and Refreshment Houses Bill, the Clerks of the Peace Removal Bill, the Militia Ballots Suspension Bill, the College of Physicians Bill, the Trespass (Ireland) Bill, the Militia Pay Bill, the Local Government Act (1858) Amendment Bill, the Cathedral Minor Corporations Bill, the Railways (Ireland) Acts Amendment Bill, the Drainage and Improvement of Lands (Ireland) Bill, the Inclosure (No. 2) Bill, the Thames Embankment Metropolis Improvement (Loans) Bill, the Isle of Man Harbours Act Amendment Bill, the Divorce and Matrimonial Clauses Amendment Bill, and several railway and other private bills.

NAVAL ENGINEERING.

The Russian Navy.—In The Artizan recently we stated that Messrs. Charles Mitchell and Co., iron shipbuilders of Newcastle, had been commissioned by the Russian Government to adapt one of the existing dockyards in St. Petersburg to the purpose of building iron armour-plated vessels of all classes, and that all the heavy machines required for the various operations of iron shipbuilding were manufactured in different parts of England, and were afterwards erected under Messrs. Mitchell's supervision in Russia. On the completion of these erections, this English firm entered into a contract with the Russian Government to construct some of these ironclads in the St. Petersburg dockyard, and intelligence has been received that the first two ships have been safely launched. The following are particulars of their construction:—The *Ne tron Menya* (*Touch me not*), the larger of the two iron-clads just launched, is 230ft. long, 53ft. broad, and 27ft. deep. She is covered from stem to stern with armour 5½in. thick at the water-line, and 4½in. on the remaining surface of the sides, on a backing of teak 12in. in thickness. The armament will consist of 20 200-pounder rifled steel guns. The machinery is of 450 horse-power, and in addition there is an auxiliary engine for working large pumps and driving a fan blast to ventilate all parts of the vessel. The draught of water of the *Ne tron Menya*, when fully equipped for service, and with her coals on board, will be 15ft. The launching draught was 9ft. 9in., the entire armour being on the sides, with the exception of 25 plates at the bow, and the same number at the stern, which it was thought desirable to fix after the vessel should be afloat. A rifle turret similar to the one built on the *Warrior* is placed on the upper deck, is covered with 4½in. armour, and is provided with electrical apparatus to convey the captain's instructions to the gun deck, the engine-room, and the steersman. As the *Ne tron Menya* is destined chiefly for coast defence and for service in the Baltic, she will only be lightly rigged. The second ironclad, launched together with the *Ne tron Menya*, is a double-turret vessel named the *Smertch* (*Waterspout*), and is about the same size and tonnage as the Danish iron turret ship *Rolf Krake*. The chief dimensions are as follows:—Length 190ft., breadth 38ft., and depth 14ft. The draught of water when in fighting trim will be 10ft. 6in., the armour is 4½in. thick, and extends the entire length of the side, and to a depth of 4ft. below the line of flotation. The armament is carried in two revolving turrets constructed on Captain C. P. Coles' system. These turrets have an internal diameter of 18ft., and are each capable of carrying two large guns; but being the first turrets on Coles' system made in Russia, it is wished that every facility should be given to insure a successful result, and in this instance but one 300-pounder gun will be placed in each turret. The armour on the turret varies from 6in. to 4½in. in thickness. The top of the turrets and the surface of the upper deck are covered with plating one inch thick. The hull is constructed with double bottom and sides, for the purpose of affording safety in the event of the outer shell of the vessel being pierced by a shot, or being run into by an enemy. The space between the outer and inner bottoms is also divided by transverse bulkheads into numerous watertight compartments, each furnished with pipes for pumping out in case of leakage, or for filling with water to increase the immersion of the vessel, and thereby diminish the surface above water exposed to the enemy's fire. The machinery for the *Smertch* has been manufactured by Messrs. Maudslay, Sons, and Field, and is of 200 horse-power nominal, divided into two distinct pairs of engines, 100 horse-power each, for the purpose of driving twin or double screws. The object of such arrangement is to usefully absorb the entire power of the engines, which could not be done so well with one screw on so limited a draught of water, also to give the vessel increased power of manœuvring while in action. For a like purpose a balanced rudder has been fitted in the bow of vessel. The *Smertch* will be rigged as a three-masted schooner, the fore and masts being of iron, and constructed on Captain Coles's tripod system.

Spanish Naval Arsenal.—We extract the following from the *Moniteur de la Flotte*:—The naval arsenal of Ferrol (Spain) is situate in a magnificent bay, quite a lake, sheltered from every kind of adverse wind and surrounded by high mountains. The magazines are well stocked, the foundries are extensive establishments, the implements are of English manufacture and bear the Manchester mark. Many of the masters and workmen are English. Two engines of 1,000 horse-power, two of 500, and one of 250, are being constructed and nearly finished. One of the engines of 1,000 horse-power is destined for the iron-clad frigate the *Prince Alphonzo*, and one of the 500 horse-power engines for *Almanza*, 50 guns. The other engines will be sent to Carthagena, Ferrol is the only Spanish arsenal in which engines are constructed; at Cadiz or Carthagena repairs only are made. There are very few ships at Ferrol. Six old dismantled ships are in port; the *San Francisco* is undergoing repairs. The iron-clad frigate the *Tetouan*, launched two months ago, is being equipped. She is a magnificent ship, measuring upwards of 255ft. at the waterline. The *Tetouan* will carry 1,200 tons of fuel and four months' provisions for 500 men. Her masts and rigging are to be those of a second-class frigate. Her iron plating has been made in France. She will be ready to put to sea in four months hence. A timber frigate, the *Almanza*, 50 guns, will be soon launched. Three new slips of granite are about to be constructed. There is at present but one dock at Ferrol, of inconsiderable size, but another is being built which will be upwards of 400ft. long. In front of the town and outside of the arsenal the Government is constructing an artificial harbour for merchant ships.

The "Dauntless," 31, screw steamship, 580 horse-power, having undergone most extensive repairs, both of hull and machinery, in the large basin at Sheerness, previous to her departure for the Humber as coastguard at that station, has been taken to the measured mile off Maplin Sands for the trial of her engines. Two runs were made with full boiler power, which gave a result of 9·290 knots per hour; the draught of water on the trial was, forward, 17ft. 5in.; aft, 18ft. 8in. The trial at the measured mile is reported to have been very satisfactory.

The "Fawn," 17, screw steam sloop, 751 tons, 100 horse-power, was taken to the measured mile off Maplin Sands on the 11th ult. for the final trial of her machinery previous to her departure from Sheerness for the protection of the Scotch fisheries. The draught of water was 14ft. 1in. forward, 14ft. 11in. aft; the load on the safety valve was 20lb.; steam in the boilers at full power, 20lb.; at half-boiler power, 17lb.; the vacuum, 27¾; the revolutions of engines—maximum, 90; minimum, 85·33. An average speed of 7·239 knots was obtained at boiler power; 6·016 knots at half-boiler power; the force of wind being 4, easterly. She had 80 tons of coal on board, and all her sea stores and armament. She is fitted with Smith's propeller, with the leading corners cut off; the diameter being 10ft.; pitch, 12ft.; length, 2ft.; immersion of screw, 2ft. 6in. The trial was considered very satisfactory.

Naval Appointments.—The following appointments have taken place since our last: J. W. M'Kenzie, promoted to Engineer, supernumerary to the *Asia*; G. Park, of the *Majestic*, promoted to First-class Assist.-Engineer; C. J. Franks, of the *Cumberland*, promoted to Engineer; W. Castle, of the *Dauntless*, for tenders, confirmed as Engineer; J. T. Robinson, supernumerary of the *Cumberland*, confirmed as First-class Assist.-Engineer; T. W. Tandy, Chief Engineer to the *Fisgard*, for the *Favourite*; G. Mills, Engineer to the *Asia*, for the *Whiting*; J. Ellis, Acting Engineer to the *Cumberland*, for the *Linnet*; G. Tyrer, Assist.-Engineer to the *Indus*, for the *Doris*; M. J. Shannon, Assist.-Engineer to the *Fisgard*, for the *Prince Albert*; T. W. Davenport, Acting Assist.-Engineer to the *Asia*, as supernumerary; C. Icely, Chief Engineer to the *Caledonia*; J. Downes, Chief Engineer to the *Clio*; W. Oliver, Chief Engineer to the *Royal Sovereign*; F. G. Barr, Chief Engineer to the *Asia*, for the *Immortalité* when paid off; W. Ash and J. W. M'Kenzie, Engineers to the *Royal Sovereign*; R. Hetherington, Engineer to the *Clio*; V. Horne, Assist.-Engineer to the *Caledonia*; J. M'Intyre, Henry Onions, J. Dinwoodie, and H. W

Wilkins, Assist.-Engineers to the *Royal Sovereign*; R. H. Cooper, Assist.-Engineer to the *Cumberland*, for the *Wildfire*; W. Gentles and J. T. Coombs, Assist.-Engineers to the *Clio*; H. C. Jones, Engineer to the *Fisgard*, for hospital treatment; H. G. Pilcher, Engineer to the *Enterprise*; R. Burridge, Assist.-Engineer to the *Cumberland*, as supernumerary; T. Q. Butler, supernumerary in the *Asia*, confirmed as Second-class Assist.-Engineer; J. Watson (a), Assist.-Engineer to the *Fisgard*, as supernumerary; H. Leslie, Engineer to the *Asia*, for the *Volcano*; A. Lloyd, Engineer to the *Asia*, for the *Pheasant*; J. Hall (b), Assist.-Engineer to the *Clio*; W. Crow, confirmed as First-class Assist.-Engineer in the *Fisgard*; W. Fenton (a), Assist.-Engineer to the *Frederick William*; G. Whiting, Assist.-Engineer to the *Edgar*, for the *Trunculo*; H. Payne, Engineer to the *Fisgard*, as supernumerary; A. Aitken, Engineer to the *Asia*, as supernumerary; W. Ironmonger, Engineer to the *Asia*, for the *Skylark*; W. J. Sprake, Engineer to the *Galatea*; E. Lilley, Engineer to the *Indus*, for hospital treatment; J. Oldfield, Engineer to the *Cordelia*; J. T. Downing, Assist.-Engineer to the *Indus*, as supernumerary; J. H. Ferguson, Assist.-Engineer to the *Asia*, as supernumerary; F. Martin, Engineer to the *Hastings*, for the *Rose*; J. G. Barrow, Engineer to the *Rattlesnake*, for the *Pioneer*; W. H. Sedgwick, Assist.-Engineer to the *Rattlesnake*; J. M. Watson and G. H. Barnes, Assist.-Engineers to the *Rattlesnake*; J. Rice and D. Miller, Engineers to the *Duncan*, as supernumeraries; E. Ingledew, Engineer to the *Bulldog*; W. Hooper, Engineer to the *Indus*, for the *Fervent*; J. West, Engineer to the *Marlborough*, as supernumerary; T. Green, of the *Defence*, and I. M. Murphy, of the *Majestic*, promoted to be Engineers; F. E Julian, Acting Engineer to the *Majestic*; J. Duffield, of the *Shannon*, T. Jeans, of the *Rifleman*, and W. J. J. Spry, of the *Medea*, promoted to be Acting Engineers; W. Rumble, First-class Assist.-Engineer to the *Marlborough*; R. Young and J. Phillips, Second-class Assist.-Engineers to the *Marlborough*; W. Rowley and R. E. Chisnell, Second-class Assist.-Engineers to the *Duncan*; W. Green, Second-class Assist.-Engineer to the *Irresistible*; C. J. Serjeant, Chief Engineer to the *Urgent*; F. Gundry, A. G. A. Billowes, and W. Pratt, Assist.-Engineers to the *Urgent*; J. H. Hewlett, Chief Engineer to the *Indus*, for the *Encounter*, when paid off; P. M. Knight, Assist.-Engineer to the *Bulldog*; J. Adams, Assist.-Engineer to the *Indus*, for hospital treatment; G. T. Ludlow, Assist.-Engineer to the *Asia*, as supernumerary; G. J. Weeks, Assist.-Engineer to the *Himalaya*; T. F. P. Shelley, of the *Asia*, J. Taylor (b), of the *Salamis*, G. Purkes and J. E. Warner, of the *Marlborough*, promoted to be First-class Assist.-Engineers; A. J. Tout, of the *Jason*, J. Nelson, of the *Rinaldo*, J. Ferguson (b), of the *Forte*, G. Quick of the *Rattler*, and J. Imrie, of the *Hesper*, promoted to be Acting First-class Assist.-Engineers.

MILITARY ENGINEERING.

Trial of Armour-plates at Portsmouth.—A trial of armour-plates took place at Portsmouth, on the 18th ult., under the superintendence of Capt. A. C. Key, C.B., of Her Majesty's ship *Excellent*. A plate manufactured from steel by Mr. George Wilson, of Sheffield, of the now minimum plate thickness of 4½in. was tested. Two ordinary wrought iron plates were also tried, one being of 6in. thickness, from the Millwall Iron Works and Shipbuilding Company, and the other being a thin end plate for the *Pallas* of 4½in., from Messrs. Beale, of the Parkgate Water, Sheffield. In all previous trials of steel armour-plates at Portsmouth, they have invariably, from their hard brittle nature and want of fibre, cracked through in all directions under the blow of the 68-pounder cast-iron shot, and this was especially the case with some plates that were specially made from the steel of the Elswick Works and cooled in oil under the superintendence of Sir W. Armstrong. In the trial of the steel plate at Portsmouth, on this occasion, it was found to be soft, fibrous, and without any exhibition of cracks beyond the circumference of the indents made by the shot except in one instance, and then only to the extent of four inches. There was also but a very trifling opening of the lamination at the edges of the plate, and one shot that struck the plate on its left lower edge spread the metal out considerably without cracking. The specific gravity of the plate was stated to be 7·835, and it cost from £10 to £15 per ton in excess of the price now being paid by the Admiralty for wrought-iron plates. The diameter of the indents produced on it by single shot, was 9in., and the depth of the indents ranged from 2in. to 2 8-10ths. One shot overlapping a former indent 5in. produced or rather increased the former indentation to 4in. In another case the shot overlapped 3in., and increased the depth of the indent to 8in. The plate received eleven shots altogether. The Millwall 6in. wrought iron plate received twelve shots in a comparatively small space in its centre, several of them overlapping each other without any material damage. The thin 4½in. plate of Messrs. Beale did not, owing to its 25 per cent. less thickness of metal, come out of its trial quite so victoriously as the Millwall plate, but it was struck in two places by three shots overlapping each other. Although it was necessarily in these two places broken through, the shots were destroyed in the operation and the plate was shown to have qualities which would have rendered the ship practically invulnerable.

STEAM SHIPPING.

Steam Shipbuilding on the Clyde.—Messrs. W. Denny and Brothers have launched an iron screw of 1,025 tons, the property of the British India Steam Navigation Company. This vessel is exactly similar to several others built by Messrs. W. Denny and Brothers for the same company. The engines, by Messrs. Denny and Co., are to be of about 180 horse-power. Mr. A. Denny, of Dumbarton, has launched a paddle named the *Lamar*, intended for blockade-running. The *Lamar*, which is being engined by Messrs. Napier, is the third vessel of the same kind built at Dumbarton within the last few weeks. The *Lafayette*, the second of the steamers built on the Clyde by Messrs. Scott for the French Compagnie Generale Transatlantique, has left Scotch waters for Havre. She is a sister steamer to the *Washington*, built by Messrs. Scott for the same company. A third steamer, of similar dimensions, is now on hand in Messrs. Scott's yard for the same company, and will shortly be launched. Messrs. M'Nab and Co. have launched the *Warsaw*, a steamer of 500 tons, built for the Leith, Hull, and Hamburgh Steam Navigation Company, and intended to be employed between Leith and Hamburgh.

Novel Iron-clad River Vessel.—The *Kahireh*, built for the Viceroy of Egypt, and intended for the service of the Nile, made a trial of her powers on the 16th ult., in the Thames, for the inspection of the Lords of the Admiralty, before proceeding on her voyage to Egypt. This vessel is of 348 tons burden, by Messrs. Samuda Brothers, with engines of 50 horse-power, by Messrs. John Penn and Son, is entirely cased in armour two inches thick from stem to stern, and reaching from the gunwale to two feet below water. She has two semicircular cupolas, or shields, on deck, one forward and the other aft, each of which contains a long 18-pounder gun, and is also entirely covered with armour plates two inches thick. Notwithstanding all this large amount of armour protection, the draught of water of the craft, with her guns, stores, coals, and provisions all on board, was something less than four feet, and the mean speed obtained by the vessel was nine knots per hour. The limited draught rendered two screws advisable, and these are arranged to work one under each quarter. The powers of the vessel were tested in every way by Admiral Drummond, and she was found capable of manœuvring and steering in the most satisfactory way, making the complete circle in 3min. 25sec.

Trial Trip of the "Venetia."—The first-class screw steamer *Venetia*, built by Messrs. Mitchell and Co., of Walker, Newcastle-on-Tyne, for the London, Italian, and Adriatic Steam Navigation Company, made her trial trip to the Mucсombe Light and back on the 23rd ult. Her engines, which were made by Messrs. Maudslay, Son, and Field, have been specially planned to take up as little room as possible, so as to allow all available space for the tonnage of cargo. They are three in number, and nominally of 250 horse-power. During the whole of the trip they worked admirably, and gave the greatest satisfaction to the representatives of both Messrs. Maudslay and the company who were on board. Although very much down by the stern in consequence of the after bunkers being filled with coal, while the forward position of the vessel was nearly empty, she made nearly twelve knots an hour in running the measured mile, a high rate of speed for a cargo boat. Although designed specially to carry merchandise, a certain number of first-class berths have been reserved for passengers. The *Venetia* will trade between London and Genoa, Leghorn, Naples, and Sicily, and will call at intermediate ports when necessary. She is the sister ship of the *Adria*, and will make the sixth vessel put on this line by the company, who have three or four more on the stocks.

New Channel Steamboat.—The South-Eastern Railway Company are about to place another fast steam vessel on the Folkestone and Boulogne Station—a companion ship to the *Victoria* and *Albert Edward*. The new vessel is named the *Alexandra*, and is of the same dimensions and power, viz., 570 tons burden, 205ft. length, 24ft. breadth, and 220 horse-power, built by Samuda Brothers, with engines by Penn and Son. At the trial of the *Alexandra*, at the measured mile, in Long Reach, she was found to surpass her predecessors, having maintained a speed of 17 nautical miles, or equal to 19¾ statute miles per hour.

LAUNCHES.

The Launch of the "Favourite," armour-plated screw-corvette, took place on the 5th ult. The *Favourite* was originally intended for a 21-gun corvette, her keel having been laid on the 23rd of August, 1860, but she was subsequently converted into an iron-clad. She has been completed under the superintendence of Mr. Reed, the Chief Constructor of the navy. She is to carry ten guns, six of which will be 110, and four 100-pounders. Her armour plates will be 572 tons, and her engines of 400 horse-power. The following are her dimensions:—Length between perpendiculars, 225ft.; ditto for tonnage, 262ft. 8½in.; ditto of the keel for tonnage, 195ft. 6¾in.; breadth extreme, 46ft. 9½in.; ditto for tonnage, 44ft. 10½in.; ditto moulded, 44ft. 2½in.; depth in hold, 25ft.; burden in tons, builders' measurement, 2,093 76-94. After the launch her draught of water forward was found to be 8ft. 9in., and aft, 16ft. 3in.

Launch of a Cunard Steamer.—On the 20th ult., an iron screw steamer, intended for the Cunard American service, was launched from the building yard of Messrs. Tod and Macgregor, Glasgow. The new vessel, which has been named the *Cuba*, presents the following dimensions:—Length of keel and forerake, 327ft.; breadth of beam moulded, 42ft.; depth moulded to spar deck, 29ft. The tonnage is 2,832 by builder's measurement. The *Cuba* will be propelled by oscillating engines of 650 horse-power nominal, fitted with surface condensers and all the latest improvements. She will possess accommodation for 300 first-class passengers, and if it should at any time be deemed desirable to employ her as a troopship, she would be found capable of transporting 1,500 men. The rig will be similar to that usually adopted in the Cunard ships, Cunningham's patent reefing topsails being employed, and the masts being furnished with Sir Snow Harris's lightning conductors as applied to iron ships. A duplicate ship to the *Cuba*, to be named the *Java*, is at present being built for the Cunard Company by Messrs. Thompson, of Govan, and is expected to be launched in February, 1865.

TELEGRAPHIC ENGINEERING.

Telegraphs in New South Wales.—The only telegraphic works at present in progress in this colony are three branch lines, which are being carried out under an arrangement with the residents in the several districts that the Government shall receive five per cent. on the outlay. On the line from Braidwood to Queanbeyan a distance of fifteen miles has been cleared, and holes for the posts have been sunk for a distance of thirteen miles. The posts are all erected on the line from Deniliquin to Hay, and fifteen miles of wires are stretched. The line from Wellington to Dubbo has been commenced. The estimates for 1864 being at length passed, tenders will shortly be called for new lines for which money has been voted. These consist of extensions from Mudgee to Murrurundi, and from Braidwood to Araluen, and the continuation of the line to Cooma.

Telegraph round the World.—The proposed intercontinental telegraph which *viâ* Behring's Straits, will complete the circuit of the world, was recently the subject of discussion in the New York Chamber of Commerce. It appears that Russia has undertaken a line of 6,000 miles, from Moscow to the Pacific Ocean, at the mouth of the Amoor, of which 4,000 miles, from Moscow to Irkutsk are in operation, and that she has granted to Mr. P. M. Collins, of New York, a concession for thirty-three years to extend this line up to and across Behring's Straits, and then through her American territories to the frontier of the British possessions, a distance in all of 4,500 miles; that the British Government has granted a similar privilege down to the northern frontier of the United States; and that an application is now pending in the Washington Congress for like permission, through that country; thus connecting the whole telegraphic system of Europe and Asia, with the telegraphic system of America. The Chamber unanimously resolved to memorialise the president and both Houses of Congress in favour of the undertaking. The total distance overland by way of Behring's Straits, which are only 39 miles wide and 160ft. in depth, will be about 16,000 miles; but how the influence of the glaciers which must inevitably cross the path of the wire is to be obviated, it is hard to say. That glaciers rip up the ground whenever they reach shoal water is well known; and the wire must cross the shoals as well as the deeps. It is asserted that messages have been repeatedly sent during the present year from Boston to San Francisco, a distance of 3,000 miles, in two minutes.

RAILWAYS.

Railways in Venezuela.—The Central Railway Company of Venezuela has been incorporated under the Companies Act, 1862, with a capital of £500,000, in shares of £50 each, for the construction and working of a Central Railway in the Republic of Venezuela, under a concession and important guarantee from the Government. The first section embraces a line from Puerto Cabello to San Felipe—a distance of about 54 miles. By the decree and concession the company is secured 9 per cent. interest for twenty years upon all calls paid by a cession of import duties, exemption from taxation for forty years, right to import materials for the railway for twenty-five years' duty free, a free grant of the land necessary for the line, stations, and other buildings, and of 30,000 acres in addition, for which land warrants will be issued on the completion of the line. The estimated revenue from goods and stock traffic, based upon the present position of the country, reaches £95,000 per annum; this is exclusive of minerals, from which an additional revenue is expected. It is considered that the enterprise will yield a dividend of over 18 per cent. upon the capital of the company.

Railway Schemes.—The Commons' Select Committee on Parliamentary Deposits have reported to the house that the Act requiring the promoters of a railway bill to deposit money or stock to the amount of 8 per cent. of the estimate, in order to insure the *bonâ fide* character of the undertaking, is evaded by the new system which has sprung up. It was intended that stock so deposited should be the proper funds of the promoters, and available for the purposes of the undertaking; but now a banker or insurance company lends the stock required, depositing it with the Accountant-General in the lender's own name; and under arrangements which secure complete power over it. One or two persons thus obtain a temporary loan to make a colourable deposit, until they see whether a bill will be obtained, and whether they can enlist a sufficient number of supporters of their scheme. In the meantime they may cause by their notices great depreciation of property, and destroy the confidence in the permanency of occupation necessary for the carrying on an extension of business in large towns, and the progress of building operations. They

may prevent the completion of sales, and put parties opposing them to enormous expense. They may also subject Parliamentary committees to lengthened investigations without there being adequate means to form a judgment whether the public has taken such an interest in the undertaking as to justify Parliament in granting the powers sought for. The committee mention that in this present session more than half the deposits on private bills are made by other persons than the promoters. Mr. Stewart, the secretary of the London and North-Western Railway Company, stated to the committee that he does not believe there was a company, in the sense intended by Parliament, for any one of the new metropolitan railway projects. They have been promoted only by professional men on the chance of being able to turn them to account. An engineer, a solicitor, a Parliamentary agent, and a contractor apply for a bill; if the bill is lost, only the money out of pocket is charged, and they divide this loss among them; if the bill is granted, they set the rights so obtained up to auction. The committee recommend regulations in regard to a subscription contract, a preliminary inquiry into its *bona fides*, and the financial arrangements of the "company," the application of the deposits when returned, and its liability in certain cases for costs of opposition, all which they hope will tend to check these abuses.

Railway Revenue for the Present Year.—The revenue of our railways has been making great strides, the following being the returns on the first quarters of the last two years:—

	1863. £.	1864. £.	Increase. £.
Week ending January 2	498,460	540,820	42,360
" " 9	483,543	524,361	40,818
" " 16	490,231	533,795	43,564
" " 23	488,746	544,926	56,180
" " 30	503,835	563,916	60,081
" February 6	499,816	552,977	53,161
" " 13	499,290	535,706	36,416
" " 20	496,770	533,257	36,487
" " 27	504,243	533,269	29,326
" March 5	525,277	545,776	20,499
" " 12	515,266	540,465	25,199
" " 19	502,868	551,185	48,317
" " 26	526,484	601,625	75,141

In the first quarter of 1864 the receipts were thus £7,102,378, as compared with £6,534,829 in the corresponding three months of 1863, showing an increase of £567,549, or 8·67 per cent. The average extent of railway worked during the quarter was 11,151 miles, against 10,752 miles in the corresponding period of 1863, showing an increase of 399 miles, or 3·71 per cent. The receipts thus gained on the mileage during the past quarter to the extent of 4·96 per cent. In the second quarters of the two years the course of the revenue was as annexed:—

	1863. £.	1864. £.	Increase. £.
Week ending April 2	557,680	591,015	33,335
" " 9	550,809	597,554	36,745
" " 16	554,698	596,162	42,064
" " 23	558,425	605,700	47,275
" " 30	552,906	613,725	60,819
" May 7	563,844	614,645	50,801
" " 14	551,769	647,336	91,567
" " 21	589,087	676,090	87,003
" " 28	604,763	630,148	25,385
" June 4	571,025	628,806	57,781
" " 11	561,487	636,667	75,180
" " 18	585,473	651,395	65,922
" " 25	608,387	660,404	52,017

In the second quarter of the year the receipts were thus £8,139,647, as compared with £7,413,753 in the corresponding three months of 1863, showing an increase of £725,894 or 9·79 per cent. The average extent of railway worked during the quarter was 11,221 miles, against 10,812 miles in the corresponding period of 1863, showing an increase of 409 miles, or 3·78 per cent. The receipts thus gained on the mileage during the past quarter to the extent of 6·01 per cent. For the six months the aggregate receipts appear from these figures to have been as follows:—

	1863.	1864.	Increase.
First quarter	£6,534,829	£7,102,378	£567,549
Second quarter	7,413,753	8,139,647	725,894
Total	£13,948,582	£15,242,025	£1,293,443

This increase of £1,293,443 represents an advance of 9·28 per cent. The average extent of railway worked during the six months was 11,186 miles, against 10,782 miles in the corresponding period of 1863, showing an increase of 404 miles, or 3·74 per cent. The receipts thus gained on the mileage to the extent of 5·54 per cent.

The Atlantic and Great Western Railway is now completed, having been opened throughout on the 21st June last from New York to St. Louis, a distance of 1,200 miles, and passengers may proceed from one extremity of the line to the other without change of carriage. This important railway is destined to be the great passenger, mail, and freight route between Boston, New York, and Philadelphia, on the sea board, and Cleveland, Cincinatti, Chicago, and St. Louis, and other principal cities of the lake district and the Valley of the Mississippi.

RAILWAY ACCIDENTS.

Railway Accident in Canada.—About one hundred emigrants, men, women, and children, have been killed, and many more injured, at St. Hilaire-bridge, on the Grand Trunk Railway of Canada, by the train running into an open drawbridge, and carriage after carriage falling into a canal, 70ft. below the line of railway. The driver is under arrest, but asserts that from some cause he could not stop the engine, although the rule was to regard the drawbridge in approaching it to be always open, so that trains uniformly came to a complete stand near the bridge. The passengers were chiefly Germans, Poles, and Norwegians, in families.

Accident on the North-Eastern Railway.—An accident occurred upon the North-Eastern Railway, on the night of the 16th ult. The Great Northern Scotch express train, which left King's-cross at ten o'clock a.m., heavily laden with visitors coming to the Royal Agricultural Society's Show, at Newcastle-on-Tyne, and with many passengers for Scotland, shortly after crossing the Victoria Bridge which spans the river Wear, and as it was approaching the village of Washington at a high speed, met with a serious casualty. Through some accident the engine, No. 109, which was drawing the train broke its fore-wheels, and ran for above 100 yards, tearing down the telegraph posts, and doing other mischief to the permanent way. The engine at last stopped itself by forcing the fore end in contact with the ground, and the carriages next to the engine were thus brought up with a sudden shock, and one overran the other, doing a large amount of damage, and throwing the passengers about. Except from the shock the passengers in the middle and hinder end of the train did not receive any serious injury, but the passengers in the compartments of the foremost carriages were greatly shaken, and some of them are seriously injured.

Accidents on the Great Eastern Railway.—On the afternoon of the 13th ult. a fatal accident occurred on the Great Eastern Railway. An up train, run in connection with the new line of Rotterdam steamers, started from Harwich at 2.55 p.m. The train, in addition to the engine and tender, comprised four carriages and two breaks, and most of the passengers were from the Continent. It was proceeding at the usual speed, when, on arriving within half a mile or so of Bradfield Station, seven or eight miles from Harwich, the engine suddenly left the rails and went off the line to the right, down the slope. The whole train was thrown off the metals, and the break next to the tender was shattered. With all expedition the passengers were extricated from their perilous position, and it was found that only four or five were injured, and those not seriously. The fireman was unfortunately killed when the engine went over.—An accident, unattended with any serious result, occurred to the Parliamentary up-train from Wells, on the Great Eastern Railway, on the 16th ult. On nearing Fakenham and immediately before descending the steep incline which leads into that station, the axle of the tender attached to the engine broke. As it happened when the train was pulling up at the signal the only result was the stoppage of the line for about an hour and a half.

BOILER EXPLOSIONS.

Manchester Association for the Prevention of Steam Boiler Explosions.—The ordinary monthly meeting of this Association was held on June 28th, when the chief engineer presented his report, of which the following is an abstract:—"During the last month 272 engines have been examined, and 419 boilers, 22 of the latter being examined specially, and one of them tested with hydraulic pressure. Of the boiler examinations, 364 have been external, 8 internal, and 47 thorough. In the boilers examined, 154 defects have been discovered, 2 of them being dangerous. Details of these will be found in the following tabular statement, in addition to those of the previous month, which there was not room to include in the last report:—

Description.	Number of Cases met with: Dangerous.	Ordinary.	Total.
Defects in Boiler.			
Furnaces out of shape	1	4	5
Fracture	2	8	10
Blistered Plates	...	3	3
Corrosion—Internal	...	17	17
Do. External	4	15	19
Grooving—Internal	...	12	12
Do. External	...	5	5
Total number of Defects in Boiler	7	64	71
Defective Fittings.			
Feed Apparatus Out of Order	...	2	2
Water Gauges ditto	1	14	15
Blow Out Apparatus ditto	...	44	44
Fusible Plugs ditto	...	6	6
Safety Valves ditto	...	3	3
Pressure Gauges ditto	...	26	26
Total number of Defective Fittings	1	95	96
Omissions.			
Boilers without Glass Water Gauges	...	12	12
Ditto Pressure Gauges	...	3	3
Ditto Blow Out Apparatus	...	40	40
Ditto Feed Back Pressure Valves	...	54	54
Total Number of Omissions	...	109	109
Cases of Over Pressure	1	5	6
Cases of Deficiency of Water	...	1	1
Gross Total	9	274	283

The particulars of No. 12, 13, and 15 explosions, which were postponed from the last monthly report, are now given. No. 12 explosion, resulting in the death of one person, and in serious injury to another, occurred at an ironworks to a plain cylindrical egg-ended boiler, fired externally, and not under the inspection of this association. The boiler was one of a series of five connected together, and working side by side, being No. 4 from the left hand. Its length was 40ft., its diameter 6ft., and the thickness of the plates three-eighths of an inch; while the pressure of the steam was 35lb., which was quite moderate for a boiler of such dimensions. It had rent into eleven fragments, which were scattered in every direction, one of them being thrown to a distance of 200 yards. The character of these rents was peculiar. The majority of boilers of this class divide into two parts at one of the transverse seams of rivets, but this one had not only rent transversely, but also longitudinally, from one end to the other, so as to divide the boiler in the main into four nearly equal parts; while these were again subdivided, and the shell ultimately broken up into the eleven pieces just named. These rents were by no means confined to the lines of rivets, but had run through the solid plates entirely regardless of them, in many cases continuing for several feet within a few inches of the overlaps, and though so near, yet without running into them, but continuing in a straight line parallel to them. This gave the ruptured boiler a very anomalous appearance, as if it had been shattered rather than rent, and nothing definite was concluded at the inquest with regard to the explosion. The boiler had been originally plated longitudinally, but on the seams over the fire giving way some time since, it had been repaired with three widths of plate laid transversely. These plates, which were 3ft. wide each, extended to a short distance behind the fire bridge, and it was at the ring seam of rivets that connected the new plating laid transversely, with the old laid longitudinally, that the primary rent occurred, and which it will be seen was situated, as is so usual in these cases, near to the bridge and at the bottom of the boiler; while the anomalous manner in which the boiler had rent was due to the combination of the transverse and longitudinal modes of plating. The manager of the works informed me that their externally-fired boilers were a source of constant annoyance and expense, through getting out of repair, and it was no uncommon thing for one of the ring seams, a little behind the fire bridge, suddenly to rend through the line of rivet holes, merely in consequence of the slight change of temperature induced on the stokers' cleaning out the fires with the door open. The fact of these externally-fired boilers being ever found to give way in this treacherous manner, seems to me a sufficient reason to condemn them, especially at ironworks where the value of the

charge of metal in the blast furnaces, which far exceeds that of the boilers, is jeopardised by them. No. 13 explosion took place at a colliery. In this instance three persons were killed, and three others injured; while the boiler, was the outer one of a series of three, and, as in the case of the previous explosion, was of plain cylindrical egg-ended construction, and externally fired. The boiler, which was plated longitudinally throughout, was 32ft. long, 6ft. 6in. in diameter, and made of plates three-eighths of an inch in thickness, the pressure of steam being 35lb. per square inch. The primary rent occurred at a longitudinal seam of rivets over the fire, which after running in a straight line for some feet developed transversely, dividing the shell into three fragments, all of which were thrown to a considerable distance from their original seating; while in addition, the adjoining boiler was dislodged, and turned up on end by the force of the explosion. When it is stated that the plates at the fractured part proved to be very defective, and also that this boiler had leaked for some time at the seams over the fire, so that the introduction of bran had been resorted to in order to stop it, it will not be necessary, after what has already been said on the danger of these externally-fired boilers, to add anything further to account for this explosion; while it will appear that these boilers, whether plated longitudinally as in the present instance, or transversely as according to the more usual practice, are alike prone to explosion. No. 15 explosion, by which one man was killed, was due to the collapse of the combustion chamber of a boiler of the double furnace or breeches class, working at a flour mill. The boiler was the left hand one of a series of three, the shell being 7ft. in diameter and 26ft. 6in. long; while the diameter of the furnaces was 2ft. 9in., and that of the flue 3ft. 3in.; the length of the combustion chamber being 4ft. 6in., the thickness of the plates three-eighths of an inch, and the steam pressure 45lb. The boiler had been built by a first-class maker, and the quality of the material as well as the character of the workmanship appeared to be good throughout. The rush of steam and water from the rent in the combustion chamber drove the boiler about 6ft. forward into the firing space, and although the other boilers remained unmoved, yet the steam pipe connections to them were broken. The collapse of the combustion chamber had taken place, not at the crown but at the underside, and this arose from the fact, that while the crown was stiffened with roofing stays, assisted by tie rods connected to the shell of the boiler, the bottom of the combustion chamber was comparatively unstayed, having but a single angle iron running longitudinally on the centre line, in addition to a small gusset on each side. These breeches or combustion chambers have already proved a very fruitful source of explosion, and it is important that any steam users, who are employing boilers of this construction, should have these chambers stayed with vertical water tubes, which act as internal columns or struts, and thus prevent the top and bottom plates of the chamber coming together; while, in addition, it is frequently, if not always desirable, that the flue should be encircled with an angle iron hoop just at the waist or termination of the breeches piece. In some cases, where the pressure is low, this hoop of itself would be sufficient, and under many circumstances would perhaps be more easily obtained than the water tubes. Had these precautions been adopted in the boiler under consideration, the collapse of the breeches or combustion chamber, and the consequent explosion, would have been prevented. The following is the tabular statement of explosions for the present month, from May 28th, 1864, to June 4th, 1864, inclusive:—

Progressive No. for 1864.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
16	May 30	Locomotive	0	0	0
17	June 18	Plain Cylindrical Egg-ended. Externally fired	3	1	4
		Total.................	3	1	4

No. 16 explosion occurred to the boiler of a locomotive engine while attached to a passenger train, just after it had stopped at a railway station. The engine was of the ordinary type for passenger traffic, and built in the year 1849. The boiler rent in the barrel or cylindrical portion of the shell, which was composed of three belts or widths of plate. The belt adjoining the fire-box was completely severed from the remainder of the boiler, having rent close to one of the overlaps at a longitudinal seam below water line, and also through the line of rivet holes of the entire ring seam on each side of it. This belt was flattened out and thrown to the right; while the steam dome, in consequence of the previous rupture, was torn away, and blown to a considerable distance; added to which, the crank axle was broken, the wheel on the right hand side disturbed, and the tubes bowed ontwards; the remainder of the boiler receiving but little damage. On examining the edges of the fractured plate it was clear that the primary rent had occurred at the edge of the overlap of the longitudinal seam of rivets, for there a deep furrow was found which had eaten away the strength of the plate. These longitudinal furrows are the most frequent source of locomotive boiler explosions, and there appears to be no other way of detecting the silent progress of these furrows in time to renew the weakened plates so as to prevent rupture, than that of making more frequent internal examinations. No. 17 explosion. The scene of this explosion has been personally visited, and the ruptured boiler examined; but the investigation of all the circumstances was not completed in time to admit of the particulars being given in the present report."

BOILER EXPLOSION IN CORNWALL.—On the 3rd ult. an explosion of two steam-boilers occurred at Camborne Vean Mine. Grose's engine is a pumping-engine of 60in. cylinder, the steam for working which was generated in two boilers, which were old and worn very thin in the bottom; at the time of the disaster the steam stood at 30lbs. to the inch, when a plate in the upper part of the boiler suddenly gave way, forcing the boiler from its place and raising one end almost perpendicularly through the roof, at the same time carrying away the steam pipe connected with the other boiler, from which a plate was violently ripped, causing a second explosion. The walls of the boiler-house were completely levelled with the shock, and the debris of the roof, &c., lay scattered in the surrounding fields. It was fortunate that the explosion took place in the night, as the place was used as a dry for the miners' clothes, and several persons are generally in the house in the day-time.

DOCKS, HARBOURS, BRIDGES, &c.

THE NEW BRIDGE AT BURTON-ON-TRENT.—The bridge which replaces old Burton Bridge, crosses the river in a straight line, giving an even carriage roadway of 20ft., with two causeways, each 5ft. wide, making the total width 30ft. within the parapet walls, which are 4ft. high. The total length is 470ft., or more than a quarter of a mile, and there are 32 openings. Of these all but two are arched, the two exceptions being covered with iron girders, so as to give the height for the passage beneath them of locomotive steam engines and trains. In addition to the main bridge there are three smaller ones branching from it, and forming outlets to occupation roads. One of these, consisting of three arches leads to the Hay, one of four arches to the Broadholme, and a third of five arches to the Burton Meadows. The bridge is of stone from Whatstandwell. The arches are lined underneath with Staffordshire blue bricks, but the quoins, piers, and parapets and the whole face of the bridge, are of stone. The piers rest on gravel beds, the foundations having been carried down to these by removing 12ft. or 14ft of loose shingle, &c. The cost of construction is about £20,000.

GAS SUPPLY.

THE GAS PRODUCTS UTILISING COMPANY.—This company, with a capital of £150,000, in shares of £10 each, has issued its prospectus. The object of the enterprise is to purchase the freehold manufactory, plant, and business of the Metropolitan Alum Works, which have been carried on for several years, with highly remunerative results, by Mr. Croll, to whom the Tottenham and Edmonton Gasworks, the Winchester Waterworks, and the Gas Meter Company's works (the profits from which now average 12 per cent) formerly belonged, and who was also the founder of two London gas companies, now paying 14 and 15 per cent. each. The purchase-money has been fixed at £39,040, the greater portion of which is in shares not entitled to dividend until the general body of shareholders have received 6 per cent. The stock is to be taken at a valuation. Besides the freehold of the works, plant, and goodwill, the purchase includes four patents for the United Kingdom, two of which are being advantageously employed in the manufacture of alum; one for the preparation of materials for disinfecting purposes; and another for the preparation of materials to be employed in purifying gas, whereby waste products in chemical manufactures (to be readily obtained in any quantity) are used as agents in the purification of gas. By this process the gas is improved in illuminating power, freed from ammonia and carbonic acid, from a considerable portion of its sulphuretted hydrogen, bisulphide of carbon, and its various combinations of cyanogen, thus effecting a material improvement in this public necessity, and at the same time obtaining valuable commercial products. Mr. Croll is to receive a royalty of 30s. for each ton of material used by the company for purification of gas and disinfecting purposes. Drs. Letheby and Alfred S. Taylor have reported most favourably upon the processes, and the gas purifying material is now in general practical use at several metropolitan and provincial gasworks.

THE STAFFORD GAS COMPANY have resolved to reduce the price of their gas from 5s. to 1,000 cubic feet to 3s. 9d.

THE ROTHWELL GAS AND COKE COMPANY, at Kettering, have decided upon erecting a house and coal shed at the works.

THE BRIGHTON GAS COMPANIES have determined to reduce the price of gas to private consumers to 4s. 9d. per 1,000 feet, instead of 5s. as heretofore. It is proposed to still further reduce the price to 4s. 9d. per 1,000 feet next year.

THE BOSTON GAS COMPANY's directors have determined to recommend to the shareholders a dividend of 8½ per cent.

WATER SUPPLY.

WATER FOR CREWE.—The well at Whitmore and the reservoir at Madeley, which the London and North Western Railway Company have been constructing for some time at great cost, for the purpose of supplying their works at Crewe and the town with pure water, are approaching completion. The water main from the town is now laid to the reservoir at Madeley. The well is 12ft. in diameter inside and has been sunk about 80ft. deep in the sandstone rock, with a bore-hole 18in. in diameter, 150ft. below that. The reservoir will hold from 12 to 15 millions of gallons. An abundant supply of water has been secured, and it is said to be so pure that no filter beds are needed.

CHELTENHAM WATER SUPPLY.—The prospectus of a new water company for supplying Cheltenham with water has been issued. The capital is estimated at £125,000, which it is proposed to raise in shares of £5 each, and the water is to be conducted from the springs at South Cerney.

APPLIED CHEMISTRY.

PREPARATION OF ANILINE GREEN.—The first notice of the reaction which produces aniline green was made by M. Eusebe, who dissolved crystallised aniline red in a mixture of alcohol with sulphuric, hydrochloric, or some other acid, and added a certain proportion of aldehyde or wood spirit. The solution becomes at first violet, and passes gradually to a bright blue. (The changes, however, are not constant.) Hyposulphite of soda is now added, and the mixture is heated, when the mixture assumes a beautiful green colour. The above process has many inconveniences; but the colour may be easily and quickly produced in the following way:—150 grammes of crystallised sulphate of rosaniline are dissolved in 450 grammes of cold diluted sulphuric acid (three parts of acid to one of water). When the solution is complete 225 grammes of aldehyde are added, the mixture being stirred. The whole is now heated in a water-bath. From time to time a drop of the mixture is taken up with a stirring-rod dropped into slightly acidulated water, and as soon as a deep green solution is obtained the reaction is stopped. The mixture is now poured into 30 litres of boiling water, and to this solution is gradually added 450 grammes of hyposulphite of soda, dissolved in the smallest possible quantity of water. The whole is now boiled for some minutes. All the green remains in the solution, which may be used to dye silk. The green is very beautiful, especially in artificial light, which distinguishes it from all other shades of the same colour.

UTILISATION OF BRINE.—Another has just been added to the many instances in which purely scientific research has led to the development of the arts and manufactures. Mr. Alex. Whitelaw, of Glasgow, has invented and patented a process for the treatment of the hitherto waste brine of salted meat, so as to produce therefrom nutritive and wholesome extract of meat and portable soup. His process is the first practical application of Mr. Graham, the Master of the Mint's recently-made, curious, and interesting discovery of "dialysis." Mr. Graham, after pursuing those elaborate investigations on liquid diffusion that have occupied him for many years, found, that when animal membranes (as well as some other bodies of a similar nature) were interposed between solutions of various substances and water, that "chrystalloid" bodies freely diffused themselves through the membrane into the water; but to the "colloid" bodies, such as gum, albumen, &c., the merest film of such a membrane presented an almost impassable barrier. Mr. Whitelaw has availed himself of this principle in his process, which is of the simplest character. He can conduct the dialytic operation in vessels of various forms and materials, but the arrangement he prefers to employ as being in every respect practically the best, is a series of bladders, fitted with gutta percha necks and plugs. These bladders are filled with the previously filtered brine, and hung in rows from poles stretching across and suspended into vats of water. The water is renewed in these vats once or twice a day, and the action allowed to go on; when, at the end of the third or fourth day, it will be found that nearly all the salt and nitre of the brine have been removed, and that the liquid contained in the bladders is pure juice of flesh in a fresh and wholesome condition. This juice, as obtained from the "dialysers," may now be employed in making rich soups without any further preparation; or it may be evaporated to a less or more concentrated state, and packed in hermetically sealed tins for sale. The extract of meat thus obtained is in the highest degree nutritive and wholesome, and well adapted for ships' use, and for an army in the field. Mr. Whitelaw has also adapted his process for the use of ships at sea, for the economisation of their brine, and for the improvement of the food and, consequently, the health of the men. The quantity of brine annually wasted is very great. In Glasgow alone not less than 60,000 to 100,000 gallons are thrown away yearly; and if we take each gallon as equal in soup-producing power to 7lbs. of beef, some idea may be formed of the economic value of this process.

LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF THE ARTIZAN."

DATED JUNE 22nd, 1864.

558 C. H. Pugh—Cheese
1559 T. P. Saville—Breech-loading fire-arms
1560 J. Whitley—Railway and other wheels
1561 J. Jones—Dry gas meters
1562 G. T. Bousfield—Roving and spinning frames
1563 G. T. Bousfield—Roving and spinning
1564 G. Haseltine—Smelting and reducing ores and metals
1565 J. D. Adams—Electrical communicators
1566 T. Cullin—Paper
1567 G. Carter—Shears and scissors
1568 F. Shaw—Propulsion of steam ships

DATED JUNE 23rd, 1864.

1569 J. Holt—Opening and cleaning cotton
1570 A. Hett & F. W. Basset—Preserving animal substances
1571 J. Tirat—Galvanophysopathic apparatus
1572 J. Smith—Hats
1573 W. Clark—Railway carriage brakes
1574 E. Francis—Receptacles for tobacco
1575 W. G. Williams & J. Fraser—Spring hook
1576 R. Cochran—Treating clay
1577 A. Turner & J. Clark—Vulcanising india rubber
1578 M. Henry—Air engines
1579 J. Bailly—Ships and other floating bodies
1580 J. & J. Hinks—Lamps
1581 A. Knowles & J. Barraclough—Scribbling, carding, and combing wool
1582 W. Adams—Indicating to cab drivers the course a passenger desires to be driven
1583 W. Scarratt—Ornamenting wood
1584 D. Crowe—Applying power to thrashing and dressing machines
1585 E. R. & F. Turner—Portable engines

DATED JUNE 24th, 1864.

1586 W. E. Gedge—Bedsteads
1587 G. T. Sims & J. Pendley—Preventing incrustation in boilers
1588 W. A. Guy, E. Edwards, & R. W. MacArthur—Bread
1589 W. W. MacArthur, W. A. Guy, & E. Edwards—Dough and bread
1590 W. H. Barwell—Furnaces for supporting threads, wires, and rods
1591 W. D. Napier—Opening oysters
1592 W. Brown—Producing looped fabrics
1593 W. E. Newton—Hydrostatic scales
1594 B. Nicoll—Manufacture, ornamentation, washing, and treatment of garments
1595 Lord J. Hay—Varying positions of letters produced by stamping
1596 H. Chamberlain, J. Craven, & H. Wedekind—Ovens for burning bricks

DATED JUNE 25th, 1864.

1597 M. Henry—Governors
1598 W. E. Newton—Facilitating the loading of ships
1599 B. F. Stevens—Obtaining motive power
1600 H., J., F., & S. Jenkins—Metallic clips
1601 E. L. Berthon—Stands for telescopes
1602 C. Denis—Cooking stoves
1603 W. E. Gedge—Paper bags

DATED JUNE 27th, 1864.

1604 J. Askew—Go-carriages
1605 J. M. Johnson & J. Buckley—Balling cotton
1606 W. Perks—Beer engines
1607 H. C. & F. A. Steane—Preventing candles dropping
1608 W. P. Savage—Drains and drain tiles
1609 W. F. Thomas—Sewing machines
1610 W. Stevens—Carts and waggons
1611 W. Clark—Moderator lamps
1612 W. Clark—Feltiug machines
1613 W. E. Newton—Blowing bubbles from soapsuds

DATED JUNE 28th, 1864.

1614 C. J. Sinker—Lozenges
1615 L. R. Bodmer—Washing and drying household linen
1616 T. Thomson & J. Murray—Supplying water to waterclosets
1617 W. E. Gedge—Permanent way of railways
1618 J. A. Bouck & T. Hill—Varnish
1619 G. Farmer—Buttons
1620 W. Clark—Furnaces and boilers

DATED JUNE 29th 1864.

1621 W. Hide—Boilers
1622 J. H. Wilson—Portable waterclosets
1623 H. A. Bonneville — Litho chromolitho-typographic press
1624 C. Fieliughaus—Starch and yeast
1625 T. Duffy—Umbrellas and parasols
1626 W. Clark—Cultivation of land
1627 M. L. J. Lavater & E. W. Niblett—Waterclosets and urinals
1628 R. A. Brooman—Nuts

DATED JUNE 30th, 1864.

1629 R. Balans—Jibsail rings
1630 R. Balans—Marine hooks
1631 J. Corby—Centrifugal machines
1632 A. Kimball—Sewing machines
1633 H. Field—Sorting eggs
1634 W. Brookes—Sewing machines
1635 J. Combe—Making cops
1636 M. P. W. Boulton — Obtaining power from aeriform fluids
1637 D. Gallafent—Pumps

DATED JULY 1st, 1864.

1638 F. L. H. Danchell—Removing air, gas, or vapour from tubes, pipes, tunnels, and pans
1639 T. & T. Day—Reefing and furling sails
1640 J. Plimsaul—Fire bars, lumps, and gratings for cooking stoves
1641 J. Laugton—Ventilating railway and other carriages and ships
1642 T. Nichols—Preservation of eggs
1643 C. Defries—Foot lights for theatres
1644 E. T. St. L. MacGwire—Hammocks
1645 A. Wyley & J. Grainger—Fire-arms
1646 A. V. Newton—Self-adjusting couplings for railway carriages
1647 D. McCallum—Ascertaining distances
1648 J. Ellis & J. Adams—Decanting liquids
1649 A. Thomas—Breaking stones
1650 E. Templemore—Securing corks in bottles

DATED JULY 2nd, 1864.

1651 G. F. Graham & W. Payne—High pressure cocks
1652 W. B. Davis—Preventing the fouling of ships and other vessels
1653 N. Jarvie & W. Miller—Oakum
1654 W. G. Craig—Feed apparatus for boilers
1655 W. E. Gedge—Roman candles
1656 S. Fox—Treating slags or cinders
1657 J. Lee—Levelling and splicing leather
1658 W. Jackson, T. Glaholm, & S. S. Robson—Pumps

DATED JULY 4th, 1864.

1659 J. H. M. V. B. Wisker—Protecting ships, floating batteries, forts, and artillery
1660 A. S. Tomkins—Camp stoves for cooking
1661 J. Taylor—Endless band brush
1662 J. W. Jones—Pianofortes

DATED JULY 5th, 1864.

1663 G. H. Palmer — Heating and evaporating liquids and fluids
1664 H. Messer—Caloric or heated air engines
1665 R. K. Aitchison—Steering vessels
1666 D. Blake—Steam fire engines
1667 B. C. Sykes—Making bricks
1668 W. Lloyd—Hydrocarbon gas
1669 G. Phillips—Aniline colours
1670 B. Whitehouse & C. Priestland—Wick and chimney holders for lamps
1671 J. E. Wilson—Railway carriages and wheels
1672 J. E. Wilson—Locomotive engines
1673 J. E. Wilson—Permanent way of railways
1674 E. Clifton—Brushes

DATED JULY 6th, 1864.

1675 J. B. Howell—Wringing and mangling
1676 W. E. Gedge—Album
1677 D. Tunks—Watches
1678 E. Ratcliffe & C. Ainsworth—Looms
1679 A. B. B. Von Ratheu—Locks and keys
1680 F. J. Bugg—Pressed leather
1681 B. F. Sturtevant—Boots and shoes
1682 J. Spencer—Planting potatoes

DATED JULY 7th, 1864.

1683 E. M. Marsden—Propelling carriages
1684 H. E. Skinner—Steering apparatus
1685 G. Murray—Writing machine
1686 J. H. Johnson—Reducing lead ores and refining and softening lead
1687 H. Crichley—Reaping and mowing machines
1688 W. E. Newton—Cleansing impure water
1689 W. Smallwood—Reefing, furling, and setting sails
1690 P. S. De Pinna—Artificial feathers and plumes
1691 J. Wilson—Tanning

DATED JULY 8th, 1864.

1692 C. H. Collette—Washing machines
1693 E. H. Carbutt & W. Cuts—Steam hammers
1694 L. H. G. Ehrhardt—Gunpowder
1695 A. Blake—Brewing beer
1696 E. J. Dixon—Railway brake
1697 A. C. Bamlett—Reaping and mowing machines
1698 G. Russell—Apparatus for carrying stretchers
1699 G. Haseltine—Piston heads
1700 S. Sharp—Ship's anchor
1701 A. Rogers—Supplying heat to steam boilers
1702 J. Middleton & J. Coulong—Grinding the card cylinders of carding engines
1703 E. Leahy—Wheels and axles

DATED JULY 9th, 1864.

1704 S. Freeman—Curing smoky chimneys
1705 J. J. Moutie—Distilling apparatus
1706 T. Sharp—Tanning hides
1707 R. A. Brooman—Presses
1708 G. Hartshorne—Packing for engines
1709 G. W. W. Webbe & F. Cant—Paints
1710 T. J. J. Greer—Ventilators
1711 W. E. Gedge—Finishing woven fabrics
1712 J. Webster—Looms for weaving
1713 M. Meisel—Thrashing grain and seed

DATED JULY 11th, 1864.

1714 J. W. Horsfall—Peat, coal, or fuel
1715 T. McGrah—Cutlery bolsters
1716 D. Stuttard—Looms for weaving
1717 J. E. Billups—Permanent way of railways
1718 A. V. Newton—Measuring the flow of liquids
1719 J. Stickland—Laying veneers on to surfaces
1720 R. A. Brooman—Electric printing telegraphs
1721 W. E. Gedge—Carriages
1722 T. Amies, W. Barford, & E. Pope—Rolling grass

DATED JULY 12th, 1864.

1723 F. L. H. Danchell — Treatment of plastic materials
1724 J. Robinson—Sharpening vertical and circular saws
1725 Z. B. Smith & J. Richards—Railway chairs
1726 B. Greenwood & I. Underwood—Hair and flesh brushes
1727 S. Carey—Calcining bones
1728 W. Hadfield—Propelling steam boats and other vessels
1729 L. Schad—Pigments
1730 C. V. de Wailly—Buttons
1731 S. J. V. Day—Wheels and axle boxes for locomotives, engines, and carriages
1732 J. Forbes—Distilling liquids
1733 J. Tomlinson & T. Brassington — Securing envelopes, cases, covers, or wrappers
1734 W. Clark—Producing designs and ornamentations by means of metallic surfaces
1735 A. Bosch—Window blinds
1736 W. Barford, E. Pope, S. Bradford—Chaff-cutting machines
1737 G. O. Wray—Portfolios
1738 W. Wood—Covering land with earth or soil

DATED JULY 13th, 1864.

1739 J. Francis—Cleaning grain and seed
1740 W. Spence—Metallic screw nuts
1741 T. T. Coughin—Obtaining motive power
1742 W. Parsons—Lever fastening for sleeve links
1743 W. L. Wise—Treating fibrous materials
1744 V. Pean & A. F. Legros—Preventing noxious emanations from dead bodies
1745 E. Kirby—Applying cop tubes to the spindles of mules
1746 J. Lewis—Bolts, rivets, and spikes
1747 G. W. Pitcher—Self-adjusting pipe wrench
1748 E. Kerruish—Apparatus for collecting money or tickets, especially applicable to omnibuses
1749 W. Weild—Pressure gauges
1750 J. Gilmour—Harmoniums
1751 B. Smith—Drawing iron, steel, and other metal tubes
1752 C. Claxton—Railway carriages
1753 P. Maitland—Boring ground for wells

DATED JULY 14th, 1864.

1754 J. S. Tucker—Railway carriages
1755 E. Borstow—Communicating signals in railway trains
1756 R. Smith & J. Booth—Paper hangings
1757 T. Boyle—Air and smoke valve
1758 J. Bernays—Propelling water, air, and other fluids and gases
1759 A. A. Croll—Purification of gas
1760 J. Needham — Breech loading ordnance and other fire-arms
1761 W. White—Umbrellas and sunshades
1762 W. Cory—Forging carriage springs
1763 T. & J. Lancaster & J. Whitaker—Spinning wool and cotton
1764 F. W. Turner—Cultivating the soil
1765 W. C. Thurgar—Protecting gardens and fields from birds
1766 R. A. Brooman—Fluoride of silicium
1767 J. Clark—Instantaneous self-acting and continuing alarum
1768 J. G. Tongue—Water wheels
1769 W. K. Westly—Preparing to be spun flax and hemp

DATED JULY 15th, 1864.

1770 J. Saunders—Indicating the density of water used in steam boilers
1771 D. B. Grove & W. Carron—Envelopes
1772 J. McGrigor Croft—Shot, shells, rockets, or arrows
1773 M. Henry—Musical instruments
1774 G. Davies—Breech-loading fire arms
1775 P. Winton—Reaping machines
1776 J. Gill—Facilitating reciprocating movements of heavy parts of machinery
1777 J. Weeks—Umbrellas
1778 J. Chalmers—Armour for ships of war
1779 T. Wickham—Calculating distances in rifle shooting
1780 I. Swindells—Obtaining hydraulic and other cement from residuums or wastes.
1781 E. Bates—Letter balances and other weighing machines.

DATED JULY 16th, 1864.

1782 T. Johnson—Washing and cleansing bottles and jars.
1783 W. Tillie—Undershirts
1784 A. A. Bonnet—Preparing chemical fumigations to the treatment of human diseases.
1785 A. Wyley—Breech loading firearms
1786 J. Clayton—Furnaces for heating and melting iron and steel
1787 Z. B. Smith and W. L. Nelson—Signalling on railway trains
1788 T. F. Hodge—Duplex machine for sewing and stitching
1789 A. Barclay—Manufacture of pig iron
1790—S. Whitehurst—Machinery for work relating to bobbins and carriages used in bobbin or net twist lace machines
1791 W. Whitley—Washing machines
1792 T. C. Ebdy—Lighting and extinguishing gas
1793 C. Askew—Permanent way of railways
1794 W. M. Cranston—Mowing machines

DATED JULY 18th, 1864.

1795 F. Seebohm—Manufacture of iron
1796 T. Wilson—Signalling on railway trains, and in securing the doors and windows of railway carriages
1797 P. G. B. Westmacott—Dressing stone, and in cutting or driving galleries, tunnels, and other works in stone or mineral
1798 F. C. Cosserat—Smoke-burning furnaces used for working metals

DATED JULY 19th, 1864.

1799 A. Espirat and E. Sauce—Complex filter
1800 E. Lea—Combined pianoforte and harmonium
1801 A. Dalxell—Holders and suspenders for holding and suspending tickets
1802 T. Bourne—Machinery or apparatus for transmitting motion
1803 J. Maynes—Looms for weaving
1804 H. E. F. De Briou—Protecting and preserving metals used in the construction of ships from corrosion
1805 J. Syme—Firearms and apparatus connected therewith
1806 O. Phalp—Reefing, furling, and setting square sails
1807 G. P. Harding—Guns and ordnance

DATED JULY 20th, 1864.

1808 C. Whittaker—Self-acting mules for spinning and doubling
1809 J. Laubereau—Motive power by the expansion and contraction of air
1810 W. E. Gedge—Checking the weight of luggage and merchandise
1811 W. H. Wilks—Firearms
1812 J. Cotton—Machinery for washing clothes, wool, and other fibres and fabrics
1813 W. E. Newton—Manufacture of and mode of applying explosive compounds
1814 A. Barton, J. Sidebotham, and T. H. Nevill—Treatment of printed or dyed calicos and other fabrics

DATED JULY 21st, 1864.

1815 E. Young—Drying and calcining iron and other ores
1816 J. R. Cooper—Breech-loading fire-arms
1817 J. Hart—Reefing fore and aft sails
1818 R. Lees—Adaptation of screw propellers for ships or vessels
1819 W. E. Gedge—Stirrups
1820 W. Booth—Rendering security to railway travelling by effecting ready and easy communication between the guards, passengers, and engine drivers on railway carriages or other public conveyances where the same may be applicable
1821 J. Whitford—Machinery or apparatus for agitating freezing mixtures for cooling wine and other liquors or liquids, and for manufacturing ice and ice cream
1822 N. Salamon—Sewing machinery
1823 A. V. Newton—Electro-telegraphic apparatus
1824 A. Topp—Machinery or apparatus for twisting and doubling cotton and other fibrous materials, applicable to the manufacture of driving bands and other purposes
1825 J. Higgins—Machinery for cleaning cotton from seeds

DATED JULY 22nd, 1864.

1826 J. Hinks—Attaching dooor and other knobs to spindles
1827 W. E. Gedge—Process or means of decongelating oils
1828 J. Moller—Marking ink
1829 F. Peskett—Rivet-making machines
1830 E. Snell—Construction of anchors
1831 C. Sanderson—Manufacture of shafts and girders, and in uniting large masses of iron for various purposes
1832 R. A. Brooman—Construction of cannon and other ordnance

DATED JULY 23rd, 1864.

1833 D. Hall—Manufacture of salt
1834 G. Stevenson—Valves for apparatus worked by steam or other fluid
1835 J. Barcroft—Apparatus for the manfacture of felted cloth
1836 A. F. Osler—Constructing and propelling ships and other floating vessels
1837 W. S. Lawson—Railway carriages for obtaining a communication by a buffer platform from one carriage to another
1838 J. Clark—Machinery for cutting slate, marble, or stone
1839 R. A. Brooman—New process for treating hemp, flax, and the waste therefrom, in order to substitute such matters for cotton
1840 P. E. Le Boulenge—Electro-balistic chronographe
1841 F. Gregory—Machinery employed in breweries and distilleries
1842 D. Barker—Manufacture of artificial fuel

DATED JULY 25th, 1864.

1843 J. Fraser—Arranging and actuating window curtains and apparatus connected therewith
1844 T. Wilson—Breech-loading fire-arms
1845 J. Bell—Combination in one of window sill and window garden
1846 J. C. White—Holding whips
1847 J. H. Johnson—Safety valves
1848 J. C. Ramsden—Reeds and healds used in weaving
1849 J. Jeffreys—Climatic apparatus
1850 J. P. Ravard—Obtaining motive power by successive and direct actions produced by the same current of high-pressure steam
1851 W. R. Newton—Machinery for mowing and reaping
1852 E. Peyton—Manufacture of cylinders or rollers of copper and copper alloy

s
.
e
e
-
;
n
d
r
d
d
d
f,
n-
le
st
*

m
be
g,
m
a-
be
th
ng
as
ne

.c-
g-
6;
is;
bb
he
er
les
he
on
2
FF
ir;
2½
at
r);
hat
on
is
alf-
ow
ich
eep
and

self

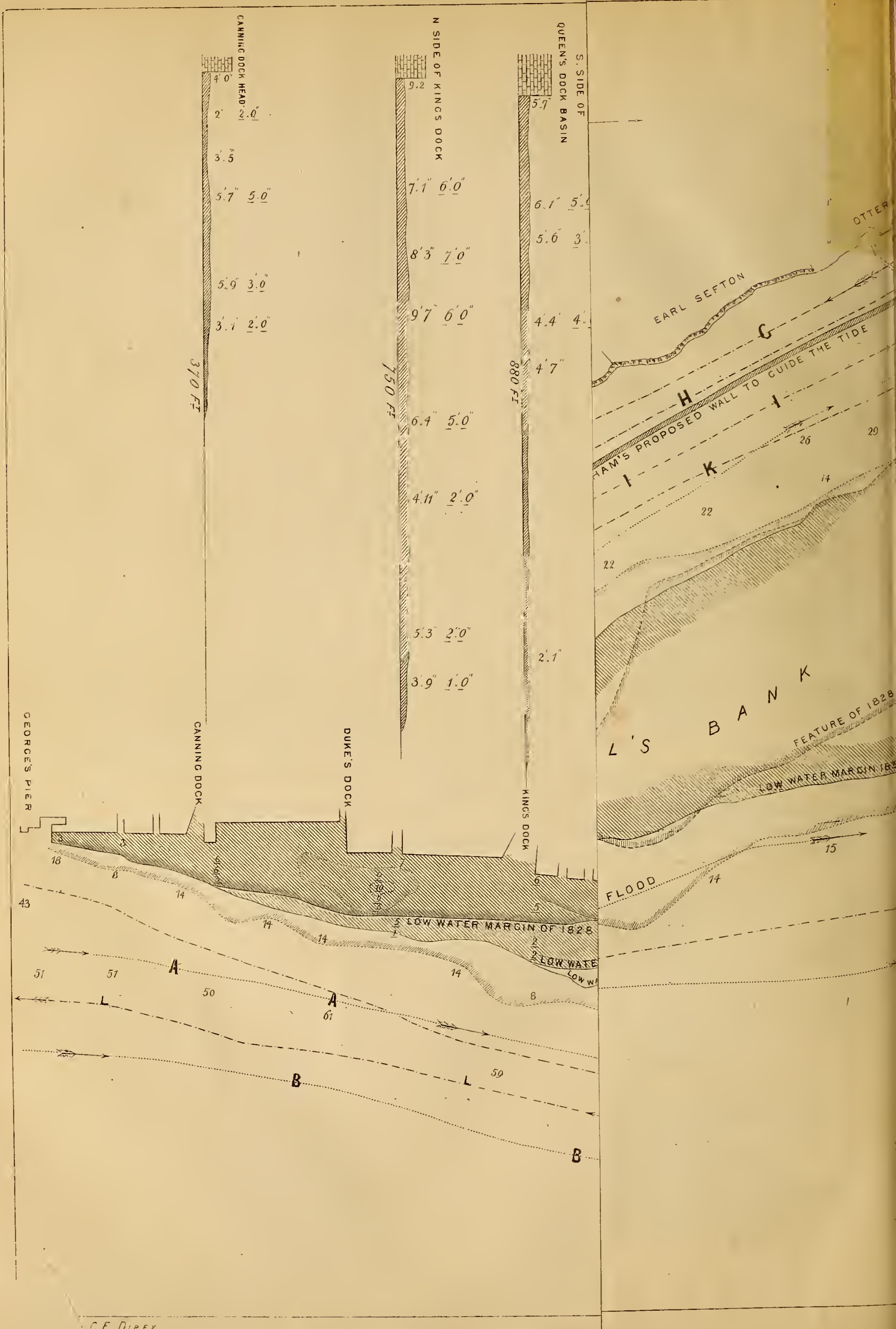


PLATE
CANNING DOCK HEAD
N SIDE OF KINGS DOCK
S. SIDE OF QUEEN'S DOCK BASIN
370 FT
750 FT
880 FT
GEORGE'S PIER
CANNING DOCK
DUKE'S DOCK
KING'S DOCK
LOW WATER MARGIN OF 1828
LOW WATER
EARL SEFTON
OTTER
HAM'S PROPOSED WALL TO GUIDE THE TIDE
L'S BANK
FEATURE OF 1828
LOW WATER MARGIN
FLOOD
C.E. DIREX.

ARY

, R. N. F. R. S.

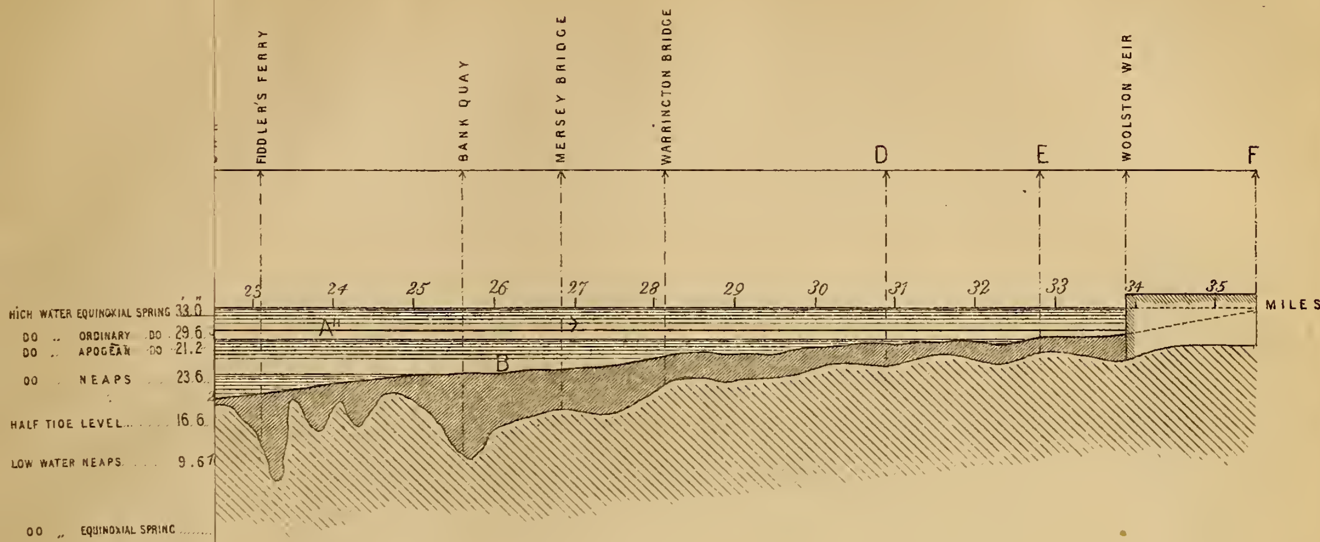


FIG. 2. PLAN OF

TER FEATURES SHOWING THE TIDAL AREA.


PLAN OF THE HIGH AND LOW WATER FEATURES
OF THE EASTERN SHORE OF THE
RIVER MERSEY,
BETWEEN
GEORGE'S DOCK & OTTERS POOL
SCALE OF FEET
DUKE'S DOCK
BRUNSWICK BASIN
DEVIL'S BANK
PLUCKINGTON SHELF
SPIT
FLOOD
LOW WATER MARGIN OF 1836
LOW WATER FEATURE OF 1836
WHOLE OF EBB DEFLECTED
LOW WATER MARGIN OF 1829

THE MERSEY ESTUARY

FROM THE SURVEYS OF CAPTN H. M. DENHAM, R.N. F.R.S.

FIG. 1.

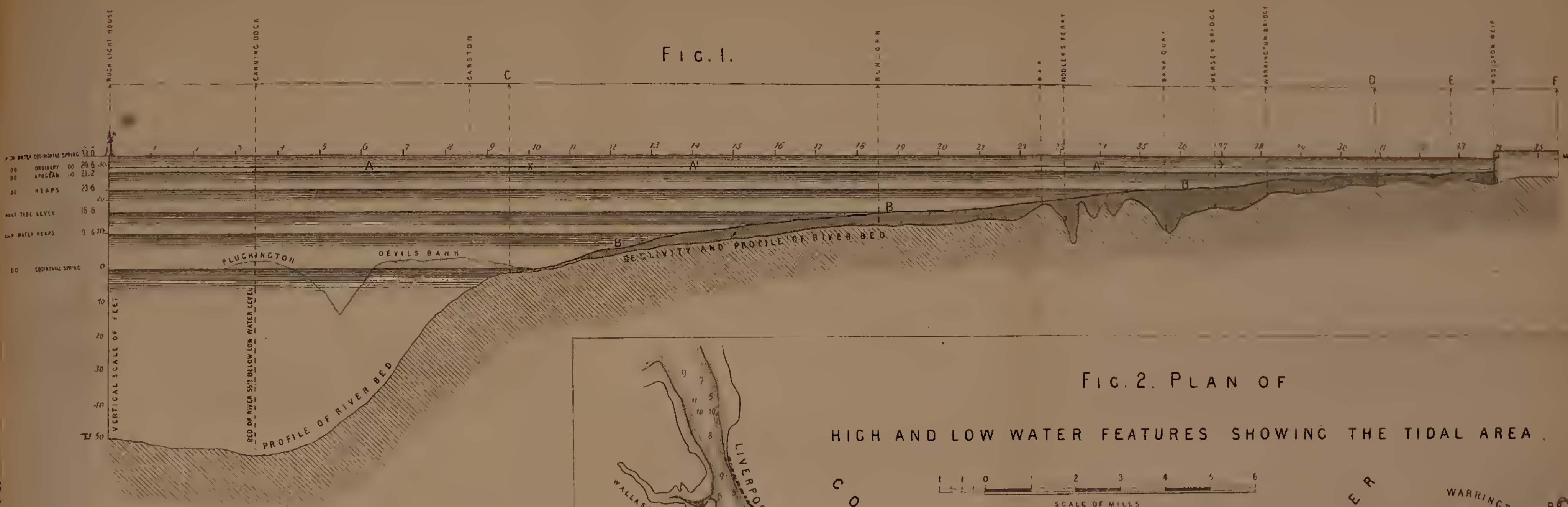
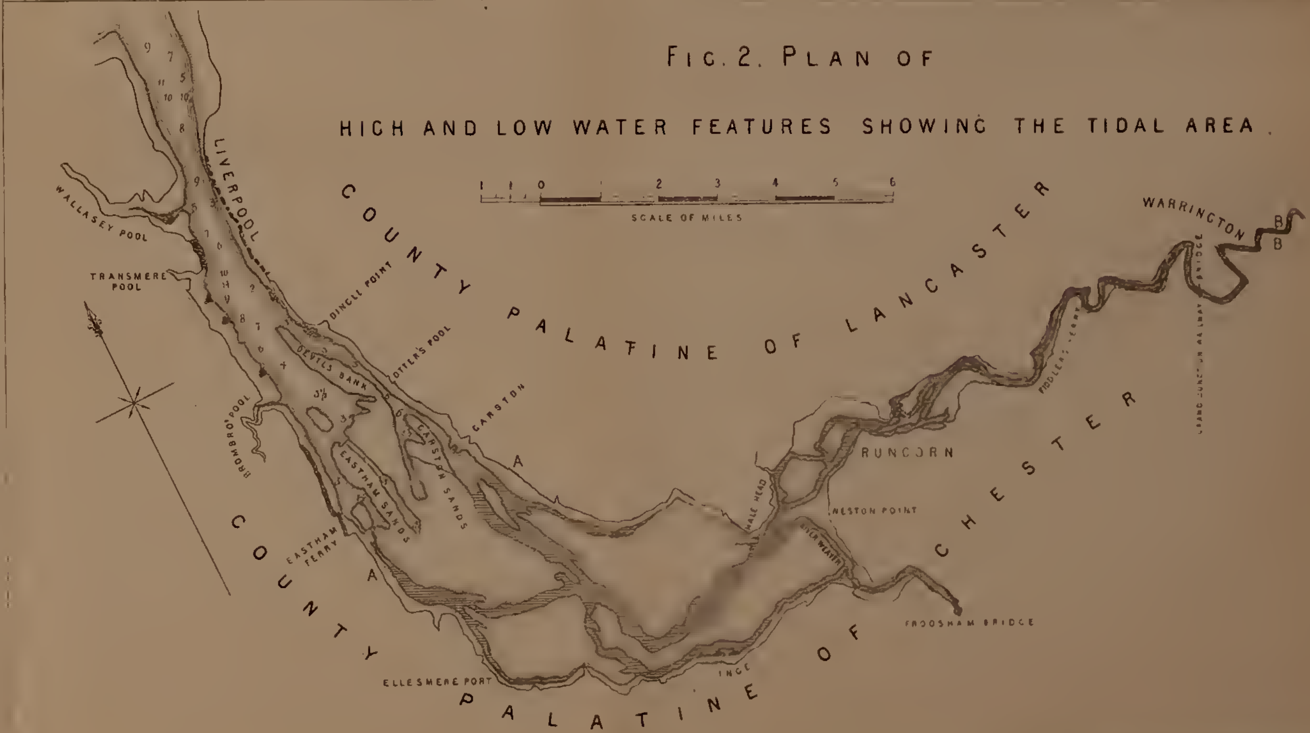


FIG. I. VERTICAL SECTION BETWEEN THE ORIFICE OF THE ESTUARY AND SUMMIT OF TIDAL RANGE.

SCALE OF MILES

FIG. 2. PLAN OF HIGH AND LOW WATER FEATURES SHOWING THE TIDAL AREA.



H. Smith C.E. Direx

1
1

1
1
1
1.
1.
1.
1.
1.
1:

1:
1:
1:
1:

15

15
15

15

15
15

15

15

15

15
15
15
15

159

159

159
159.
159
160
160
160
160

160
160
160
160

160
160
161
161
161
161

161
161

16

161
16
16
16

16
16
16

16
16
16
16

1

THE ARTIZAN.

No. 21.—Vol. 2.—Third Series.

SEPTEMBER 1st, 1864.

HISTORICAL AND DESCRIPTIVE SKETCH OF THE MERSEY DOCKS AND HARBOUR.

By J. J. Birckell.

(*Illustrated by Plates* 266 *and* 267.)

Lieutenant Denham was sent down to Liverpool by the Lords' Commissioners of the Admiralty, early in 1833, to survey the approaches to the port, and generally to discharge those duties which attach to the office of marine surveyor, in the performance of which it is not too much to say that he became one of the benefactors of this port. With such diligence did he apply himself to the task which was set before him, that on the 2nd of July, 1834, already, the Dock Committee wrote to their lordships "to express to them the high sense which they entertained of the valuable services rendered to the port by Lieut. Denham, R.N., in perfecting so excellent a chart of its approaches; in his accurate survey of the new channel, and in the very great attention he has paid in assisting to place the necessary lights, buoys, and marks;" and the spirit of scientific research with which Lieut. Denham entered upon and pursued his labours is fully illustrated by the following statement, made by him, at the meeting of the British Association in 1835, when, upon reading a paper on the approaches to the Mersey and the Dee, he said that, "he felt his attention worthily, as well as deeply interestingly, occupied when accepting a local invitation to watch and detect the salient and treacherous avenues of a channel of such vitally important intercourse."

Indeed, it appears that a more than ordinary attachment to the object of his pursuits took root within him as he proceeded with his surveys and manifold observations, for in 1840, after having resigned his post of resident marine surveyor, he published the result of his labours at his own expense, for the benefit of those whose interest lay within the port, and in the preface to his work we find him addressing the reader, as follows:—

". . . . . Six years' unremitting local attention to the sextant and leadline is enough to warrant the directions and comments contained in this volume. But the fruit of that experience would not be dispensed as it ought were I to close these remarks without disturbing the wonted satisfaction and security which present possession of eleven feet low water outlet might indulge. I therefore entreat a community, whose whole investment in commerce depends on the simple but vital issue of the mighty workings of nature, to be *watchful*."

In justification of his exhortation to watchfulness, Capt. Denham* mentions, in the body of his work, the following fact as a proof of the transitory and sportive nature of the sandbanks, both within the estuary and in the bay outside:—" The mooring grounds of the Lazarets (between Birkenhead and Brombro' and westward of Devil's Bank), shoaled up in six years 22ft., and in the following two years 11ft. more, or 33ft. in eight years, though nearly in twofold ratio the last two years of the eight. This shoaling up remained stationary for five years, when it was observed to deepen again simultaneously with the Devil's Spit and the Pluckington Shelf uniting, and the Swatchway opening through the upper part of Devil's Bank opposite Garston. The water rapidly deepened to its original depth, and moorings which had been sanded up and considered lost since 1829, were recovered in 1833. Thus, a deposit and self-removal of 2,284,880 cubic yards of sand was manifest in thirteen years, over one third of a mile in area by tidal action alone; but the question immediately presented itself, did it merely elongate towards and deposit in the deep ravine of rock which forms the trough of the Mersey, between the Docks and the Cheshire shore? This, however, was not the case, for the 60ft. depth at low water spring tides, continued and remains to this date (1840); but at the same time the following increase of the banks outside the estuary from this and other causes was registered:—The straightforward sea reach of Crosby diminished its water off Bootle 4ft. in 53; off Seaforth, 1ft. in 45, off Waterloo, 4ft. in 42, off Crosby Point 2ft. in in 37, the south-east part of Burbow bank advanced into Crosby Channel 200 yards and grew up 3ft.; the east elbow of Burbow advanced a quarter of a mile and grew up 10ft.; Middle Bank and Taylor's Spit advanced half a mile to the westward, and grew up 6ft.; the Jordan flats spread half a mile to the westward, and grew up 3ft.; the Newcome Knowl and the Three Fathom Spit formed and spread one mile and a half, growing up 6ft. and 12ft.; the Beggar's Patch in Rock Channel elongated 660 yards and grew up 5ft.; the Dove Spit advanced half a mile into the Rock Channel entrance retaining its height; and the north-east elbow of East Hayle Bank protruded into the Horse Channel 200 yards."*

Bearing these and other similar facts in his mind's eye, Capt. Denham continues as follows, in the preface of his work:—" It will not do to be lured by docks and warehouses; they will accommodate your shipping, but vigilance and incessant dedication of means can alone preserve an avenue with the ocean for their intercourse. . . . . Nor is it seaward alone the mind's eye of a spirited and confiding community must be invited: on the contrary, there exists cause off and connected with their very docks, claiming ocular conviction and demand for averting means, and as I have been asked by some, is there really such a Bank as Pluckington? I am constrained here to refer those interested in the docking of ships, to the plans and sections in appendix."

Among these plans and sections those reproduced here in Plate 266 accompanied a report to the Mayor of Liverpool on the nature of Pluckington and Devil's Banks, which report was tendered in September, 1836; the plan illustrates the courses and velocities of flood and ebb streams; and exhibits the deflecting effects of Knott's Hole Rocks upon the ebb stream and the progressive growth of Pluckington Shelf and Bank (the dotted lines marked AA indicate the first half flood tide at 3½ miles per hour; the dotted lines BB indicate the last half flood, at 4 and 3 miles per hour; the portion of this same dotted line marked CC indicates the last quarter flood at 2¼ miles per hour, the course of the flood tide on same line being written on our plate; DD the whole flood at 2, 3, and 2 miles per hour; EE the first half ebb at 2, 3, and 4½ miles per hour; FF the whole ebb from Western Channels at 2, 3, 4½, and 3 miles per hour; GG the first quarter ebb at 1¼ miles per hour; HH first half of ebb at 2¼ miles per hour; II last half ebb at 3 miles per hour; KK whole of ebb at 2, 3½, 3, and 2 miles per hour; LL last half ebb at 5, 4, and 3 miles per hour); and in his report Capt. Denham stated that these courses plainly show that Pluckington owes nothing to the flood tide, but that that deposit depends on the course of the eastern column of the ebb, and that this course is entirely governed by Dingle Point; for by practical tests on each half-hour of ebb from high or low water, its inclination was found to follow the trend of shore until within a 100 yards of Dingle Point, which becomes so decidedly the point of deflection as to hurry it into the deep water column with such impetus as to blend it with the latter and

* Promoted from Lieut.

* The reader may refer to this paragraph again with more satisfaction to himself shortly, when we shall publish the chart of the bay.

divert the whole obliquely towards Birkenhead; whereby the tidal stream of the southern portion of the docks becomes so weakened as to permit the sand held in solution to deposit there, besides being too weak to bear away the silt driven forth from the several dock sluices. To which summation of bad results we think Captain Denham should have added this one—the worst of all—namely, that thereby the whole front of the southern portion of the docks is deprived of the scouring effect of a rapid stream, which is likely to be most beneficial during the second half of ebb tide.

The first effect of this diversion, continues Captain Denham, "manifests itself in the formation of a shelf of sand varying from 3ft. to 10ft. under water, which springs from abreast the rocks (at Dingle Point), trending obliquely towards Birkenhead, until abreast of the southern extremity of the Dock Estate, where it forms an elbow ⅓ of a mile towards the centre of the river, and then trends to George's Dock; this shelf, therefore, narrows the river capacity at low water, to nearly one-half what it *appears* to be between Rock Ferry and Brunswick Dock. The visible Pluckington springs obliquely from the southern extremity of the Dock Estate, and forms an elbow off Brunswick half tide entrance (now the Coburg Dock), at an offset of 270 yards into the river; it outlays, also, King's Dock basin 270 yards, with a height above low water level of from 6ft. to 1ft., and trends to George's Dock lateral to and within 30 yards of the margin of the shelf. Its highest part is off Duke's Dock, where it outlays 50 yards less, but dries up 10ft.; off Canning Dock it outlays 120 yards, and dries up 6ft., and then gradually narrows at an elevation of 2ft., until uniting with the base of George's pier head."

"Taking the horizontal increase of this bank since 1828, (which is indicated to the left of the Plan by the dark tint of diagonally lined shading)* we have an horizontal increase of 210 yards abreast of Brunswick Basin; abreast of King's Dock 123 yards, and abreast of Duke's Dock 40 yards. Its respective elevations at the earlier date are unknown, but since 1834 it has grown up 1ft. off Brunswick Dock, 2ft. off Brunswick Basin (Coburg Dock), 3ft. off King's Dock, 3ft. off Duke's Dock, and 1ft. off Canning Dock, during which its low water margin has yielded 50 yards directly off Brunswick Basin. Simultaneously with this two years' fluctuation, I find the Devil's Bank to have warped 143 yards towards the eastern shore, lowered in altitude 4ft., but elongated towards Pluckington Shelf 250 yards, so that the spit of Devil's Bank and Pluckington Shelf are within a quarter of a mile of uniting with each other, an event which is to be feared, seeing that the Devil's Spit has elongated ⅞ of a mile in eight years, but which should be averted with all anxiety; for when the space between them is shoaled up to a bar of 6ft. instead of 15ft. below low water, the Garston branch of the Mersey will scour through the Swatchway just above Otterspool, dividing the Devil's Bank from Eastham Sands, [Plate 266,] and join the main column of ebb stream down the Cheshire side of the river.

"I therefore earnestly propose that a river wall be extended from 40 yards within the low water edge of Knott's Hole rocks, scarping the edge of those rocks and preserving a gentle concave face along the low water margin of shore. This wall would produce a most sensible effect on the first 2,400 yards of advance, by presenting a cut water edge to the down stream, instead of allowing the whole body of water to drive against the northern arm and rocks of Dingle Point, there to be jerked off with an impoverished impetus at nearly right angles to its wonted and natural course. Its further extension might be subject to convenience of funds, understanding always that as it progressed south-eastward, more decided guidance and impetus on the ebb stream would be afforded. In conclusion Captain Denham states that, whilst placing dock sills within 4ft. and 9ft. of low water level, a bank should be contemplated with much jealousy, which not only precludes taking up early anchorage near the docks, but which threatens to elevate itself above the level of those sills, except in the guttering course of the gate sluices. He further suggests that there is no need to wait for the connection of a boundary wall from the docks to Dingle Point before striking out the cut water wall southward, but to act independently and effectively from Dingle Point, by first projecting on the rocks a 100 yards, and then vigorously working towards Otterspool."

The tenour of this report, and the manner in which it is framed, seem to indicate a degree of confidence on the part of Captain Denham in tendering his advice, which left little or no doubt upon his mind that it would be accepted and carried out without material delay; the reasons, at any rate, urged therein were, or should have been, of sufficient weight to command the immediate attention of the Dock Committee, since they tended to show that report resolved itself simply into the question of keeping open the entrances of the whole almost of the docks then built. But the attention of the Committee and of its engineers, appears to have been so entirely absorbed with the scheme of northern dock extension, then necessitated by the immediate wants of the port, that Captain Denham's report was shelved, and the urgency of a southern extension of the river wall as a remedy against the growth of Pluckington does not appear to have again been pressed upon the minds of the responsible managers of the Dock Estate since that period. The consequence of this neglect has not, it is true, been quite so serious as Captain Denham apprehended it might; but in the course of our next paper we shall be able to show that, according to the latest surveys of Lieut. Murray T. Parkes, R.N., the visible Pluckington has extended several hundred feet towards the centre of the estuary, and that it has considerably grown in height at various points since the date of Captain Denham's surveys.

So impressed was the latter with the importance of this subject of the growth of the banks and shoals, and which are such a serious menace to the existence of the port, both within the estuary and the bay outside, that he, towards the same period, made a long series of experiments to ascertain the quantity of silt contained in suspension in the flood and ebb waters of the stream, the results of which, together with other highly interesting matter, he embodied into a paper read before the British Association, at their Liverpool meeting, in September, 1837. This paper was illustrated by a plan showing the high and low water features of the estuary, and a longitudinal section, showing the relative levels of high and low water, spring and neap tides, between the mouth of the estuary and the tidal head at Warrington Bridge. [Both these are re-produced here in Plate 267.] The difference in high water time being 2h. 28min. in a distance of 36 miles, with a simultaneous difference of 12ft. in the level of tidal surface. In the same series of observations the vertical action of a 32ft. spring tide and of a 14ft. range of neaps had been so noted every half hour throughout the twenty-four, and the high and low water times so detected by five minute grades, as to show that the oscillation of each vertical range, whether it be springs or neaps, passed the same line, viz., half the spring tide range (16ft.) at three hours before and three hours after every high water time, and not at the half elapsed time of high and low water. The velocity of flood tide necessary to fill the estuary, which upon full and change of moon, contains 779,174,880 cubic yards of tidal water he ascertained to be as follows:—First hour, 4 miles; second hour, 6½ miles; third hour, 7 miles; fourth hour, 5¾ miles; fifth hour, 3 miles; sixth hour, 1 mile; or 31 miles transitu, occupying 6h. 30min. The velocity of tide necessary to supply and disgorge the 292,653,200 cubic yards of contents at the quartering of the moon amounts on the flood to 15 miles, and on the ebb to 18¼ miles transitu. The excess of velocity and time attending the egress refers to the proportion of freshes, and the question how they are comparatively charged with insoluble matter had been the object of special research by means of a simple apparatus consisting of a double valve bucket, which had enabled him to bring up samples of passing stream at any depth, without mixing with the intermediate water. These samples were extracted at depths of from 6ft. to 30ft. of flood and ebb, embracing the seasons, and carried into a series which produced an average of 29in. on the flood, and 33in. upon the ebb in every cubic yard of

* The narrow dark strip of shaded tinting (marked A, B) to the right of the tinting indicating the horizontal increase of the Bank, shows the space which was in course of enclosure in 1836.

tidal water; which, taking the average of springs and neaps' circulation (or 535,914,040 cubic yards) produces 330,989 cubic yards of matter held in solution upon each flood, and 379,054 cubic yards upon each ebb, thereby evincing a preponderance of matter left in the bay upon each ebb of 48,065 cubic yards; a diurnal deposit which in tidal rotation of 730 refluxes amounts to the vast annual bulk of 35,087,450 cubic yards, which, if equally distributed over the first ebb range (64 square miles), would produce an annual layer 21in. thick. It, however, is not wholly retained in the region over which the first ebb ranges and expires, but it is disturbed, before it can adhere, by the succeeding ebb, the strength of which begins at night, just where the evanescent stage of the morning's tide deposited, over a secondary area of 41 miles, in which region a proportion of matter is held in suspension equal to $\frac{1}{3}$ of that left in the primary region; and, as even that which is left diminishes in bulk $\frac{1}{2}$ by consolidation, the actual annual quantum of measurable increase to the shallows of the bay and approaches to the port is 11,695,817 cubic yards, which, if it were disseminated equally, would increase the water by a substratum of 7in. in thickness. It is, however, not deposited in this regular way, but certain knowls and spits are fed, which, after attaining a certain growth, elongate into fresh underlays, which, by becoming tidal deflections, keep up that sportive state of the channels which the survey of the new channel (now known as the Victoria Channel) exemplifies.

That channel actually lies at a right angle to the mean set of stream, and broke through sometime between 1822 and 1832, scouring 22ft. for 2 miles nearly by $\frac{3}{4}$ of a mile broad, because the deposit at the exhausting point of ebb had been gradually damming up the last half ebb, and that half was deflected and weakened by a spit stretching into the stream within the cross deposit.

It was to watching and providing for such changes which so vitally concern the shipping of the port, that Captain Denham devoted himself, and in the course of incessant exploration of the banks and channels, he found the actual deposit during fourteen years to have amounted to 160,170,988 cubic yards, whilst that detected in transit multiplied by this interval of time would predict a deposit of 151,741,438 cubic yards, 8,429,558 as the position resulting from chance deposits, unusual freshes, and what the Helbre Swatch Branch of the Dee sends forth into the Mersey range of the bay.

There is in this attempt to detect the amount of insoluble matter of river transit, such a pleasing and successful coincidence in result that it cannot be considered hypothetical, but must be held as a positive practical means of predicting or rather ascertaining what every river is journeying forth from its valleys and banks to the bars and shoals of the port below. Thus, continues Captain Denham, may embouchure observations detect and predict the nature and amount of what is going on in the approaches to every river, either as a guide to the engineer in his bridge or dock projections, or as a hint to the marine surveyor as to vigilant delineation of the navigable regions; as a claim upon liberal appropriation for dredging and harrowing means, and as a serious appeal to the landowner, who for the gain of acres from the shore of his property in an estuary may deteriorate it for ever by the languishing of channel intercourse with the sea through eventual lack of back water.

This latter appeal, as we have shown in our last paper, has long since met with a response in the establishment of a Board of Conservancy, and in the enactment that no further abstractions shall be made without the sanction of that Board. But the generally useful and locally important teachings conveyed in this *résumé* of several years' careful and laborious observations did not soon find their way, as we shall take occasion to show, to within the reach of the engineering intelligence which, since then, has on various occasions been summoned either to advise the managers of the Dock Estate or to defend its interests.

In our Plate 266, the five sectional views there shown are transverse profile sections of Pluckington Bank, showing its comparative level with low water springs (10ft. below old Dock Sill), in 1834 and 1836; the outer figures indicating the levels in 1834.

Referring to Plate 267. In Fig. 1 the line marked A A′ A″ indicates respectively that the spring tides attain a velocity of $6\frac{1}{2}$ miles per hour, and neaps $4\frac{1}{2}$ miles; the average hourly velocity, four miles, occupying but $2\frac{1}{2}$ hours upon springs and 3 hours upon neaps; hourly velocity of springs, on the floods, $2\frac{1}{2}$ miles, and 2 miles on the ebb. The line BBB is the descent of river freshes. The vertical dotted line C indicates the extent of tidal level at low water springs; at the next vertical dotted line (at Runcorn) the tides rise 55 min. later than at Liverpool, the height of equinoctial springs being 16ft. 7in., and at neaps 8ft. 1in. At Fiddler's Ferry the tide flows 1 hour 5min. later than at Liverpool, and 10min. later than at Runcorn. At Bank Quay the tides flow 1 hour 20min. later than at Liverpool. At Warrington Bridge the equinoctial springs rise 8ft., ordinary springs 4ft. 6in., neaps rarely reach—flow 1 hours 55min. later than at Liverpool. The point indicated by the vertical line D, indicates the highest contact of tidal water with the Mersey stream at a 27ft. 2in. tide at Liverpool. The point E indicates the highest contact of tidal water with the Mersey stream at a 29ft. 6in. tide at Liverpool. The point F indicates the highest contact of tidal water with the Mersey stream (supposing the Weir removed) upon a 33ft. tide at Liverpool.

The relative times of high water and comparative rise of tide are as under:—

		H.	M.			FT.
Full, and change of the Moon.	At Canning Peir	11	5	...	Ordinary Spring	30
	Weston Point	11	45	...	„	22
	Frodsham Bridge	11	45	...	„	$14\frac{1}{2}$
	Runcorn	12	0	...	„	$11\frac{1}{4}$
	Fiddler's Ferry	12	10	...	„	9
	Warrington Bridge	12	50	...	„	$4\frac{1}{2}$

Half Tide Level of Full Tidal Range .... $16\frac{1}{2}$
which every tide arrives at and recedes to three hours before and after high water.

The following is the summary of the data arrived from the particulars given in Fig. 1, viz.:—Amount of tidal transit at orifice, $23\frac{3}{4}$ miles, impelling the flood wave to a tidal reach of $35\frac{1}{4}$ miles. The inclination of tidal surface between the summit and the orifice, when high water at summit, is 11ft. in 28 miles. Declivity of river bed between high water summit and the point where the river freshes unite with the tidal waters at low water level, 29ft. in 26 miles. Dip of the river bed between Eastham and Canning Dock, 55ft. in 6 miles. Progressive rate of tidal velocity on the flood in 35 miles, $6\frac{1}{2}$, 4, $2\frac{1}{2}$, and $2\frac{1}{4}$ miles; and on the ebb, 7, 5, 2, and 2 miles per hour. Successive retardation of tidal flow, 55min. in the first 15 miles, and 50min. in the 11 following miles. Gradations of vertical range, 16ft. decrease in 9 miles, and 8ft. in the succeeding 9 miles. Actual difference of high water time in 25 miles flow, 1h. 45min.; difference of rise in same distance, 25ft.

Referring to the Plan, Fig. 2 (Plate 267).—The points AA indicate the extent of tidal level at low water springs. The points BB indicate the highest tidal junction upon ordinary springs.

The following are the results of the data arrived at from the particulars given in Fig. 2.

	Cubic Yards of Water.
The Estuary contains high water springs	779,174,880
„ „ „ neaps	292,653,200
Or presents an average daily circulation of	535,914,040

	H.	M.
Maximum velocity on the flood $6\frac{3}{4}$ miles per hour, $23\frac{3}{4}$ transitu in	5	20
„ ebb 7 „ $29\frac{1}{4}$ „	6	30

	Cub. In.
Proportion of silt and mud suspended in every yard of ebb tide ...	33
„ „ „ „ flood tide...	29

	Cubic Yards.
Diurnal transit of silt to the bay by ebb water	379,054
„ „ returned by flood	330,989

	Cubic yards.
Annual transit of matter over the outer banks and shoals at the mouth of the Estuary	350,870,450
Actual deposit after the second tides, dissemination and consolidation after tidal pressure	11,695,817
Actual cubical increase detected by Banks, Knowls, and Spits in one year	12,296,000
Difference formed from flood transmissions when crossing the Dee	600,183

(*To be continued.*)

INSTITUTION OF MECHANICAL ENGINEERS.

ON THE PROCESSES AND MECHANICAL APPLIANCES IN THE MANUFACTURE OF POLISHED SHEET GLASS.

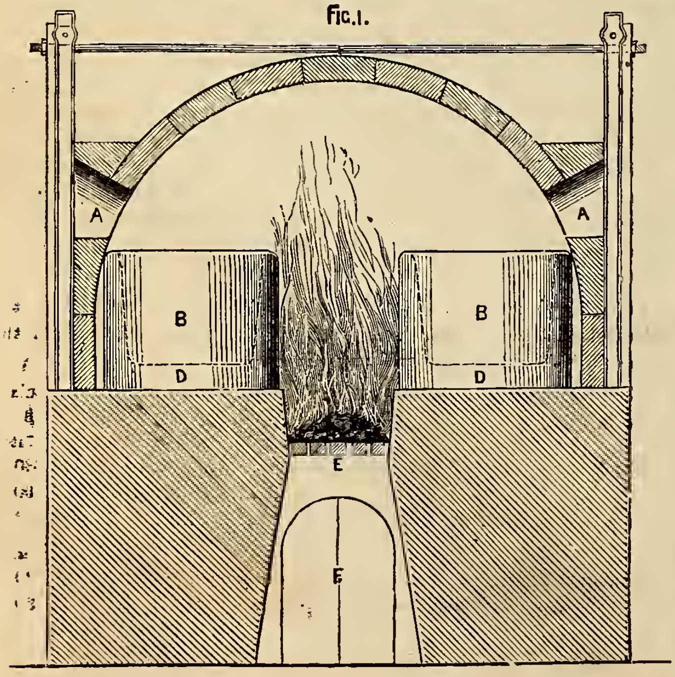
By Mr. Richard Pilkington, Jun., of St. Helen's.

The manufacture of British sheet glass was introduced into England about the year 1832 by Messrs. Chance Brothers, of Birmingham. Since then it has become generally used, having almost superseded crown glass, in consequence of the comparative ease of obtaining the large squares at present required for windows, and the absence of wave lines by which the vision is so much distorted in crown glass. The average size of sheet glass is 40in. by 30in., but if required it can be made much larger; whilst with crown glass it is almost impossible to procure a square as large as 34in. by 22in. Sheet glass when used for windows has generally a peculiar appearance when viewed from the outside of a building, on account of the unevenness of its surface, an eyesore partially obviated by the improved method of flattening, but entirely removed when the glass is polished. When polished it is known by the name of patent plate to distinguish it from British plate. This polished sheet plate has a decided preference over British plate, being harder and more difficult to scratch, beside staking a higher polish; it is also cheaper.

The manufacture of polished sheet glass consists of the three following processes:—1st, melting and blowing; 2nd, flattening; and 3rd, polishing.

1. *Melting and Blowing.*—Two furnaces are required, one for melting the materials or "frit," and the other for reheating the metal whilst blowing it into a cylindrical form. The melting furnace is a reverberatory furnace, arranged for maintaining a high temperature with great uniformity and freedom from dust or other impurities arising from the fuel. The furnace, an eight-pot one, is shown in the accompanying woodcuts, Figs. 1 and 2. There are four "gather-

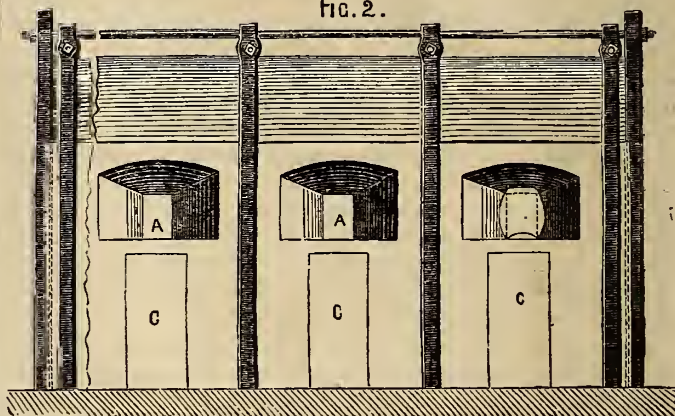
Fig. 1.



ing holes" or "working holes" A A on each side of the furnace, as shown in the side elevation Fig. 2, each of the eight pots B having a working hole. The temporary brickwork C beneath each working hole can be removed when required, either to turn a pot or whilst fixing a new one. A raised bed D extends the entire length of the furnace, upon which the pots are placed on each side of the firegrate. The firegrate E extends the entire length of the furnace, with the exception of a space of about 4ft. length, and is fed from each end of the furnace. The air is supplied through the underground passage F entering from the open air; and by means of closely fitting doors the draught is regulated with great nicety.

Formerly it was considered necessary to use stone for the melting furnaces, but at the present time large bricks made of the best fireclay have a decided preference. These firebricks vary in weight from a few lbs. to several cwts.; they are all made in moulds, dried, partially burnt, accurately dressed to templates, and built into the furnace, the whole being firmly secured by cast and wrought iron binders, as shown in Figs. 1 and 2. A small fire is lighted upon

Fig. 2.



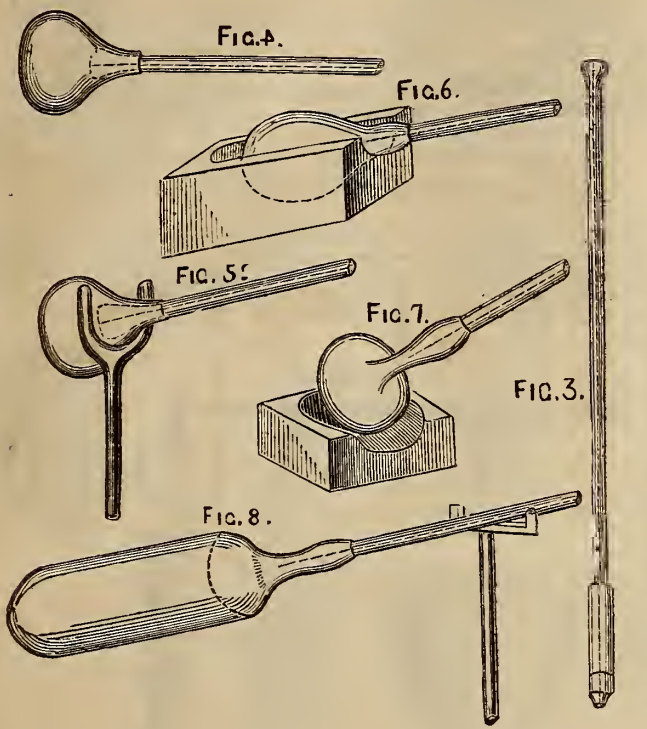
the firegrate and gradually increased, first to dry the furnace and afterwards to bake it; great care and attention are given to this operation, for upon it depends the duration of the furnace. After being baked, the furnace receives its number of pots, generally four or five on each side of the firegrate, in all eight or ten pots.

The manufacture of these pots is a matter of special importance, and they are made of the very best Stourbridge fireclay, which when thoroughly tempered is formed into rolls of about 1lb. weight each, and worked layer upon layer into a solid mass, free from cavities containing air, and making a pot of about 4ft. height inside, 5ft. diameter at top and about 4½ft. diameter at bottom inside, weighing when dried about 25cwts., and containing about 22cwts. of melted metal. Great care is requisite to prevent any particles of foreign matter or dirt from getting into the clay; for if that were to happen the pot would not last its time, but would most likely give way when first heated to the working temperature. The average duration of a pot is about eight weeks, and their estimated value about £9 each. After being made, a pot remains in the same room for a year, the temperature being maintained 60° Fahr., and it is then removed to a warmer room, where it remains in a temperature of 90° until it is wanted. When required for use it is taken to the "pot arch" to be baked, where the heat is gradually increased to that of the melting furnace, to which it is conveyed whilst red-hot as quickly as possible by means of a carriage or a crowbar on wheels, and placed on one side of the firegrate: this operation is repeated until all the pots are fixed in the melting furnace. The furnace ends are now closed, with the exception of the firehole at each end. A small portion of "cullet" or broken glass is put into each pot, and when melted is ladled so as to run down over the interior surface of each pot, after which the heat is increased for a short time. The pots are thereby glazed and are now ready to receive the material to be melted.

The quantity of raw material or "frit" allotted to each pot is filled into it in three or four charges, allowing a sufficient interval of time to elapse between each charge to ensure the previous one being melted. About sixteen hours of intense heat are required to melt the entire quantity, during which time the fluid metal boils violently, and before it can be worked requires cooling, which takes about eight hours. Whilst cooling, the small bubbles of air arising from the boiling of the metal ascend and pass away, leaving the metal clear, excepting the surface which is coated with impurities from the frit, from the roof of the furnace, and from the dust of the fuel, all of which must be removed before commencing work. Inside each pot and floating upon the surface of the metal is an annular ring made of fireclay 2in. thick, having an internal diameter of 18in.; this inner space of 18in. diameter is cleaned, instead of the entire surface of the metal, thereby saving both time and material. The cleaning or skimming is performed by means of a light iron rod, chisel pointed, which being warmed the metal adheres to it; and this process is repeated whenever any impurities are perceived upon the surface of the metal.

The surface of the melted metal being cleaned, the workman dips into it the blow-pipe, Fig. 3, having previously warmed the nose end of the pipe. Withdrawing 2lbs. or 3lbs. of the metal, he allows it to cool to a dull red, and then dips the pipe again; collecting by degrees in this way, as shown in Fig. 4, a sufficient quantity to produce a given sized sheet of glass, which on the average would weigh about 20lbs. Then while cooling the pipe he continually turns it round, drawing it towards himself, and in so doing forces the metal beyond the nose end of the pipe by means of the forked rest in which the pipe revolves, as shown in Fig. 5, leaving as little metal as possible upon the pipe. The blower now takes

the pipe and places the red-hot mass in a hollowed wooden block upon the ground, Fig. 6, keeping the pipe in a horizontal position whilst revolving it, thereby producing a solid cylindrical mass of metal. During this process his assistant allows a fine stream of cold water to run into the block from a sponge, keeping the wood from being burnt and giving a brilliant surface to the glass. He next raises the pipe to an angle of about 75°, and blows until he has pro-



duced a hollow pear-shaped mass, Fig. 7, with its largest diameter the same as that of the finished cylinder. During this operation his assistant keeps the block wet, and a second block is generally used when commencing the blowing.

The glass now requires reheating, which is done at a furnace built of ordinary brickwork in an oblong form, its dimensions being determined by the number of blowers intended to work at it, generally four, five or six at each side. The ground at each side of this furnace is excavated to a depth of about 7ft., a width of about 16ft., and the same length as the furnace; and over each of these spaces four, five or six wooden stages are erected at distances of about 2ft. apart. Having reheated the glass, the blower repeatedly blows to maintain the cylinder of equal diameter throughout, whilst lengthening it by swinging it backwards and forwards in the 2ft. space, and occasionally swinging it round over his head; until a cylindrical piece of glass is produced, Fig. 8, about 11in. diameter and about 50in. long, closed at one end and having the blow-pipe attached to the other end. The blower first opens the closed end as follows: enclosing as much air as possible within the cylinder, and stopping the mouth-piece of the pipe with his hand, he exposes the end of the cylinder to the heat of the furnace, which whilst softening the glass at the end, expands the contained air to such an extent that a small hole is burst in the glass, as in Fig. 9. This hole is flashed open by revolving the pipe quickly, and when flashed the end of the cylinder is withdrawn out of the furnace; and by keeping the pipe in a vertical position for a few seconds the metal cools sufficiently to keep its shape. The cylinder is then placed upon a wooden trestle, and by touching with a piece of cold iron the pear-shaped neck near the pipe nose at G in Fig. 9 a crack is formed, which is continued round the neck by gently striking the blow-pipe, and thus the pipe is released, as seen in Fig. 10.

The cylinder has now one end of full diameter, but the other is contracted to about 3in. diameter, Fig. 10, and must therefore be cut off. This is accomplished as follows: the cylinder having become cold whilst remaining on the trestle, the workman collects a small portion of metal upon the end of an iron rod and draws it into a thread of glass of about ⅛in. diameter by means of a pair of pinchers. This thread he passes round the body of the cylinder at H H in Fig. 10, and after it has remained on a few moments the pinchers dipped in cold water are applied to the heated part, and the sudden contraction causes the end to fly off with a sharp report, leaving the cylinder about 45in. long and 11in. diameter.

2. *Flattening.*—To produce a flat sheet of glass from the cylinder thus obtained forms the second process of the manufacture. The flattening is accomplished as follows:—The end of the cylinder that was flashed being slightly contracted in diameter and the thickness of metal much reduced, it is first necessary to cut off about 2in. length from that end; for this purpose the cylinder is supported in a vertical position by means of a cradle, as shown in Fig. 11 over a small horizontal table; the bottom edge of the cylinder is introduced between the jaws of the small cutting instrument I, and the moveable jaw carrying the cutting diamond is pressed by a spring against the interior surface

FIG. 9.

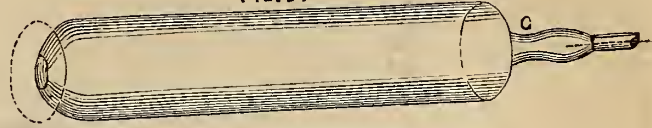


FIG. 10.

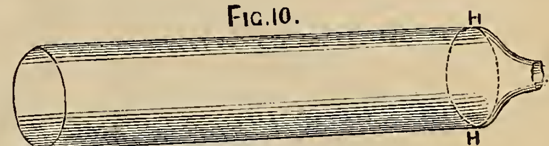
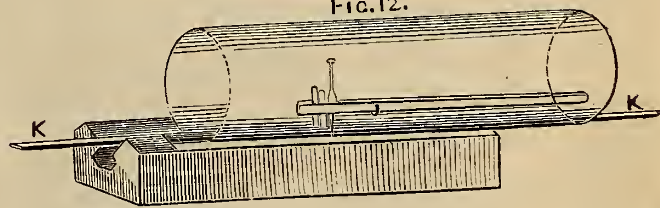
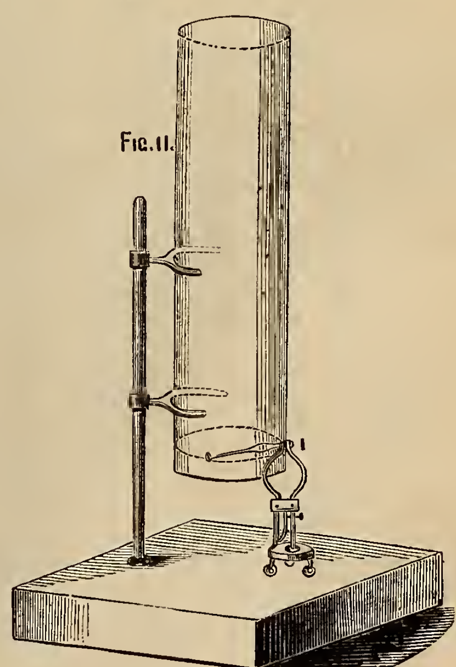


FIG. 12.



of the cylinder; then by gently pushing the instrument forwards round the cylinder, allowing it to run freely upon its wheels, the end of the cylinder is cut off perfectly true. The cylinder then requires splitting longitudinally, which is accomplished by placing it in a horizontal position in a wooden cradle, as shown in Fig. 12, and a diamond fixed in the cleft of a stick at J is drawn along inside the cylinder from end to end, guided by the straight edge K, a gentle pressure being exerted on the glass in opposite directions at the diamond cut to complete the splitting.

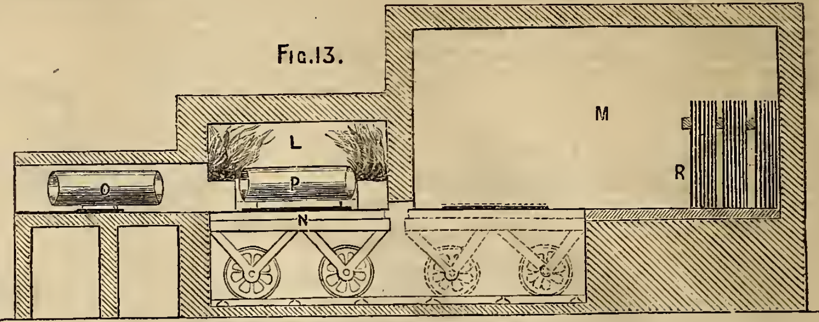
FIG. 11.



The cylinder is now taken to the flattening kiln, Fig. 13, which consists of two furnaces built together, the first L for flattening, and the other M for annealing, the former being maintained at a much higher temperature than the latter. A portion of the bottom of the flattening kiln L, slightly larger than the largest sheet of glass to be flattened, is supported upon a carriage N, which with the flattened sheet is made to travel in the annealing kiln M, this plan being a very great improvement over the old method of pushing the flattened sheet whilst

in a soft state. The moveable bed N is either of clay or stone, and by careful work is made as true as possible; upon this a sheet of glass is first flattened and left there to flatten others upon, in order to obtain sheet glass with as true a surface as possible. The split cylinder to be flattened is gradually introduced into the flattening kiln, being placed first at O and then at P, and when sufficiently warmed is placed upon the glass bed N, with its split side uppermost; the heat soon softens it, so that with a slight assistance from the workman it lies down nearly flat on the bed N, and the sheet is afterwards carefully rubbed as flat as possible with a piece of wood fixed to the end of an iron rod. The movable bed N is now pushed forwards into the annealing kiln M, as shown by the dotted lines, and after placing another cylinder to warm at O and P, the workman removes the flattened sheet from the carriage N by means of a tool like a fork, and places it upon a prepared part of the floor of the annealing kiln M, to stiffen previous to piling it. The carriage N is now returned to the flattening kiln L, and the flattening operation repeated till the carriage again appears in the annealing kiln M. The previously flattened sheet is first piled on its end against one side of the kiln at R, and then the last flattened sheet is removed off the carriage N, and left to cool on the floor of the annealing kiln like the previous sheet. This flattening process is continued until the annealing kiln M is filled, when it is closed up and allowed to cool, generally from 24 to 36 hours, the time being regulated by the thickness of the glass. On the completion of the cooling, the kiln M is opened and the sheets of glass are taken to the warehouse, where they are sorted to suit various purposes, a very large portion being packed and sent away without undergoing any further process.

Fig. 13.

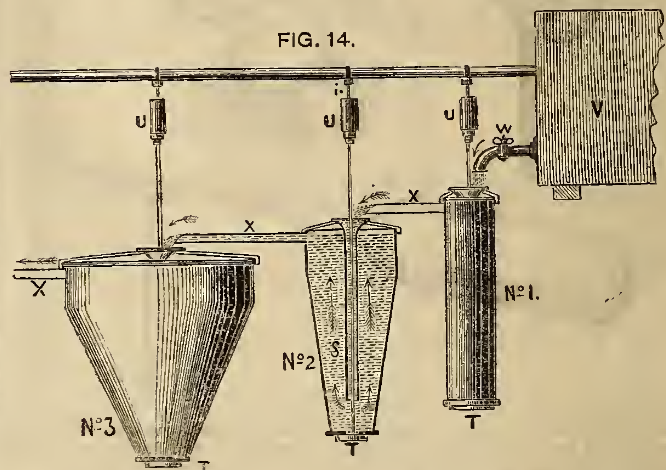


3. *Polishing.*—The sheets intended to be polished are now selected, and pass through the third process of the manufacture to produce polished sheet plate. Two processes are necessary for this purpose, smoothing and polishing.

Smoothing consists in working two sheets of glass one upon the other by hand with emery and water between them, and as their surfaces become obscured finer and finer emery is used until the surfaces are smoothed free from all defects. The apparatus used consists of a wooden bench, one half of which is 6in. higher than the other; upon the former is placed a slab of slate about 1½in. thick, larger than the sheet of glass, having as true a surface as possible. Upon this slab a sheet of glass is laid, with a piece of wet calico between the surfaces of the glass and the slab; by exerting a gentle pressure upon the glass the air is expelled from between them, and the sheet of glass is consequently held down upon the slab by the whole atmospheric pressure upon its surface, which holds it so firmly that when the sheets have to be raised from the slab many are broken, even by experienced workmen. The wet calico is used in this case instead of plaster of Paris for bedding the sheet of glass upon the table. In consequence of the close adhesion caused by the atmospheric pressure when the surfaces of the two sheets of glass get so true as to become closely in contact, it is impossible to work two large sheets one upon the other with the finest emeries, and it therefore becomes necessary to perform the latter portion of the rubbing process, with a small piece of glass, say about 10in. by 5in., until the process is completed. Both sides of the sheet of glass having been smoothed in this manner, and after careful examination found free from defect, the sheet is then handed over to the polishing machine.

The perfection of the smoothing process is entirely dependent upon the purity of the emery, and the perfect uniformity of the grain in each successive quality employed; and consequently a very perfect process of cleansing and sorting the emery is requisite. The ordinary ground emery contains, besides numerous degrees of fineness of grain, many impurities which must be removed, and the good emery must also be accurately sorted into portions varying in size of grain from coarse to the finest. For every degree of fineness a separating vessel or cylinder is required; and taking No. 1 as the coarsest quality, that cylinder is made the smallest in the series, No. 2 cylinder about twice the capacity of No. 1, and No. 3 twice the capacity of No. 2, and so on throughout the required number of cylinders. The emery sorting apparatus is shown in Fig. 14, and consists of the required number of cylinders fixed so that No. 1 cylinder is about 3in. higher than No. 2, and No. 2 the same height above No. 3, and so on. The cylinders are made of copper, and inside each is fixed a copper funnel S, long enough to reach within three or four inches of the bottom of the cylinder; and in the bottom of the cylinder is a hole closed by a wooden plug or a valve T of about 3in. or 4in. diameter, which is held up by the rod and spring balance U. The action of the apparatus is as follows:—A supply of water being maintained by the cistern V, a constant stream is delivered by means of the tap W into the funnel of No. 1 cylinder; the water descends through this funnel to the bottom and ascends through the annular space to the top of the cylinder, whence it is conveyed by the spout X and poured down the funnel of No. 2 cylinder, ascending in the annular space of No. 2, and passing by the spout to No. 3 funnel; this is repeated as often as there are cylinders, and from the last and largest cylinder the overflow is carried to a drain. When the stream of water is running through all the cylinders and also passing away at the overflow, the powdered emery to be cleansed and sorted is sprinkled into the funnel of No. 1 cylinder, and this is continued until enough has been fed to fill up to within ½in. of the bottom of the funnel. No. 1 being the smallest cylinder, the current of water through it will be the fastest, and the grains of emery left behind in this cylinder will consequently be the coarsest. The feeding of the emery is then stopped for a short time, and the stream allowed to continue until the water is running quite clear into the funnel of No. 2 cylinder; the valve T at the bottom of No. 1 cylinder is now opened, allowing the emery and water to fall into a vessel placed beneath to receive it; and as soon as the stream of water is again running through all the cylinders and passing away at the overflow, more emery is again sprinkled into No. 1 funnel. The succeeding cylinders are emptied in the same way, as they respectively become filled with the finer sorts of emery. The beauty of this process is the simplicity of apparatus required and the certainty of always obtaining an exact repetition of the several degrees of fineness in the respective cylinders. It will be observed that, in consequence of the cylinders increasing successively

FIG. 14.



in capacity, the current of water ascending in the annular spaces decreases in velocity in the same proportion; consequently the emery deposited in each successive cylinder increases in fineness over that deposited in the previous one.

For the final process of polishing the sheets of glass after smoothing, the machine used is the same as that described at a previous meeting for polishing plate glass. The polishing benches have two bars carrying the polishing blocks and working lengthways backwards and forwards over the table on which the sheet of glass is laid, which is made to travel alternately from side to side transversely to the bars. The polishing blocks are worked at about sixty double strokes per minute, and the bars carrying them are supported upon rollers at a height of 6in. or 8in. above the table. The moving table is worked similarly to the table of a planing machine, moving one way quicker than the other by a reversing motion similar to that of a planing machine bed. It is generally considered that to obtain a good polished surface the polishing blocks should not pass twice in succession over the same surface. Upon the moving table are fastened slabs made of a wooden frame covered with slates, upon which the sheets of glass to be polished are bedded in plaster of Paris. After one side has been polished, the glass is taken up and relaid, and the other side polished. The polishing blocks are about 5in. square, covered with felt and weighted with about 84lbs. each. The red liquor used in polishing is red oxide of iron, obtained by burning sulphate of iron in a reverberatory furnace to a dark red when cold, and it is then ground in water to the finest grain possible. The cutting grain of this material is about the hardest and finest that can be produced, and well worth examination by the microscope.

The New Factory Act.—The objects of this act are to provide for the effectual cleansing and ventilation of factories, and to regulate the labour of children, young persons, and women employed therein. The factories to which it applies are those used for the manufacture of earthenware (except bricks and tiles), of lucifer matches, of percussion caps, of cartridges, paper staining, and fustian cutting. An occupier of a factory not kept in conformity with this act is to be liable to a penalty not exceeding £10 nor less than £3. With the view of furthering the act a master can make rules to ensure cleanliness and ventilation, which rules are to be approved of by the Secretary of State, and if a person employed in the factory should infringe them he is to be liable to a penalty of £1. The act provides that meals are not to be taken in factories used for the purpose mentioned, and also regulates the age of children to be employed, who are not to be under eleven years of age.

CHEMICAL SOCIETY.

ON A NEW METHOD OF GAS-ANALYSIS.

BY A. W. WILLIAMSON, F.R.S., AND W. J. RUSSELL, Ph. D.

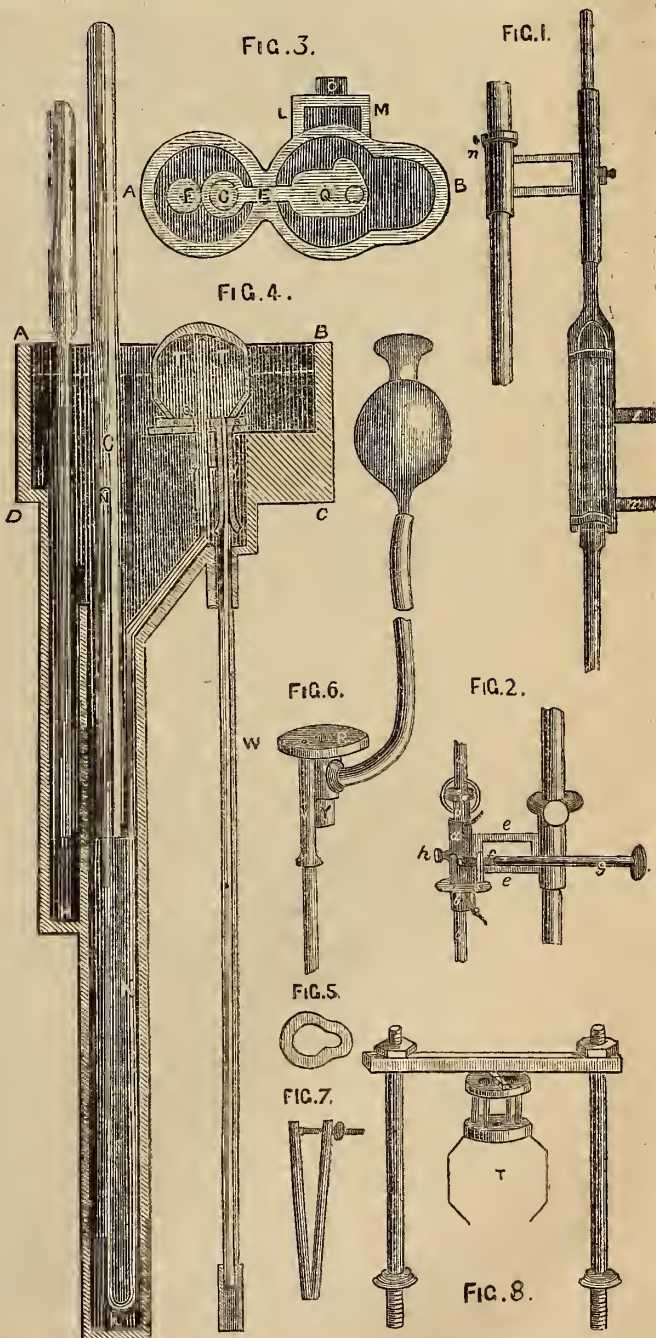
On a former occasion* we described a simple and accurate process for the measurement of gases, and its application to gas-analysis. The especial advantages of the process are that a smaller number of observations are necessary to ascertain tbe true volnme of a given amount of gas, and that the calculations necessary to deduce, from the observed volume, tbe bulk it occupies at the standard temperature and pressure, are entirely eliminated. The process thus renders tbe measurement of a gas more expeditious, and in making it a simpler operation, renders it more accurate, by diminishing the chances of error.

The principle on which the process depends is that of using, as a standard of comparison, a constant quantity of air, which is always brought to the same volume. This is effected by marking off, once for all, on the tube containing the air, the height at which the mercury stands; then the effect which any rise or fall of either the barometer or thermometer would produce on the bulk of the air, may be exactly counteracted by raising or lowering the tube in the mercury trough until the mercury again comes to tbe mark. The gas in the eudiometer has to be brought to exactly tbe same tension as that of the standard volnme of air. This is done by placing the two tubes side by side, and raising or lowering the eudiometer until the column of mercury within it is of the same height as that which is required to bring the standard quantity of air to the original volume. In the commnnication before alluded to, we described a convenient form of apparatus for measuring gases by this means, and showed its application to the process of gas-analysis described by Bunsen. Experience having long confirmed our views with regard to the advantages of this method of measuring gases, we were naturally led to attempt founding upon it a more rapid method of execnting analysis.

The forms of apparatus invented by Regnault and Frankland have proved to how great an extent the time required for making an analysis may be diminished by snrrounding the tube containing the gas with water instead of air, and by using the reagents in a liquid form; nevertheless, neither of those methods, as is well known, has come into general use. This, we believe, arises mainly from the apparatus being of too delicate and fragile a nature. In order to stand ordinary laboratory use, an apparatus of this kind must, we are convinced, be without stop-cocks or other delicate mechanism. It must also be constructed of such a form as not easily to be broken, and these requisites must be obtained without in any way diminishing the accuracy of the process. To construct an apparatus having these qualifications was far from an easy task, and it is only after considerable labour and numerous experiments that we have been able satisfactorily to accomplish this task. We will not lengthen this communication by describing the different forms of apparatus we have from time to time constructed, and the modifications which they bave undergone, bnt proceed at once to the description of the apparatus in its last and most perfect form.

The tube containing the standard quantity of air we term the pressure tube. It is represented in Fig. 1. The wide part of the tube is about 7in. long, and $\frac{3}{4}$in. diameter; in fact, it should be a piece of tubing similar to that of which tbe eudiometer is constructed. The narrow part of the tube is 17in. long, and $\frac{3}{8}$in. diameter.

The pressure tube is carried by a steel rod, 30in. long and $\frac{3}{8}$in. diameter, at the end of which is a clamp, consisting of two straight bars, $\frac{1}{2}$in. wide, $\frac{1}{8}$in. thick, which extend down the whole length of the wide part of the pressure tube. Two flexible steel rings are fastened, one near the top of these two bars, the other at the bottom. They are let into and firmly fixed to one bar, and by means of a screw passing through the other bar, the two ends of the ring can be brought together and held securely (Fig. 1). By introducing a little india rubber padding between tbese rings and the tube, then screwing the rings tight, the pressure tube is held with great firmness, and is kept in the same straight line as the rod. Firmly fastened to one of the bars forming this clamp are two other pieces of metal, *l m*, at right angles to it, passing across the back of the tube (Fig. 1). They are $1\frac{7}{8}$in. long, the upper part $\frac{1}{8}$in. thick, but narrowing gradually, so that the lower edge has only the thickness of a very blunt knife. These two cross pieces serve as marks indicating exactly where the mercury must stand in tbe tube for the contained air always to have the same volume. We use two marks, in order that when operating with only a small amount of gas, it may be consideraby expanded; but that when using a large amount of gas, it need not be expanded to the same extent. The height of the mercury in the pressure tube is altered by raising or lowering the rod in the clamp; but the final adjustment, the raising or lowering of the mercury, so that the meniscus exactly touches the lower edge of the cross piece, is performed very simply and accurately by altering the level of the mercury in the trough. This is done by screwing up or down a piece of large glass tube, which is in the further end of the trough. We shall allude again to this piece of apparatus when describing the analysis of a gas. It will be seen from what follows that it is absolntely necessary that the steel rod carrying the pressure tube be perfectly straight, and in order that it may move when raised or lowered in the clamp (Fig. 1), always in one plane, it passes through a tube, which



clasps it very accurately, and is 6in. long; in fact, the tube is made to act like a spring on the rod by having two slits cut in each end of it. The rod, when greased, slips easily through the tube, but is held firmly by it. If, however, the weight of mercury in the pressure tube should be too great for this spring to hold, the screw, *n*, is used, which by pressing against the rod, securely holds it at any point. The whole clamp carrying the pressure tube slides on one of the long, stout rods passing through the

* Proceedings of the Royal Society, vol. ix., p. 218.

tahle. A groove is cut in the top of the rod for the screw to move in. The object of this is to retain the clamp always in the same vertical plane. To render the pressure tube ready for use, a very small drop of water is placed at the closed end, and mercury poured in until only a small quantity of air remains. The tube is then inverted in the mercury trough, and more air let in, a few bubbles at a time, until when the pressure tube is brought to its proper position, the mercury within stands near the upper marker.

The tuhe containing the gas to he analysed is an ordinary Bunsen's eudiometer. It is held and moved up aud down in the same kind of way as the pressure tuhe. The only difference is that the clamp on the eudiometer is very much shorter than the one on the pressure tuhe, its length being only 3in. It is constructed in the same way, only without the two horizontal pieces at the back.

There is, however, an essential difference in the upper clamp through which the steel rod passes; to this is attached a simple apparatus for raising or lowering the eudiometer through small distances. It is similar to the fine adjustment we describeed in our former paper on the measurement of gases. Fig. 2 represents this clamp; *a* is the steel rod clamped to the eudiometer; this passes through a stout tube, *b*, and can be firmly attached to it hy a screw passing through the top of it, which is thickened for this purpose; the milled head of the screw is seen at *c*. The length of this tube is 4in. Again, this tube is within a second tuhe, *d*, which is fixed hy the bars, *e*, to the tuhe sliding over the thick rod fastened to the table. The fine adjustment is then effected in this way: a piece of cat-gut which is fastened to the end of the first tube, *b*, is wound round the axis, *f*, and passes through a hole in the centre of it. The handle, *g*, is attached to this axis, so that when it is turned round, one half of the cat-gut unwinds, while the other half wiuds round the axis, and draws the tuhe either up or down. *h* is a friction-screw moving up and down in an opening cut in the exterior tube, and is screwed into the inside tuhe *b*. On tightening this screw, it presses more strongly against the outside tuhe, thus increasing the friction with which the inside tuhe moves. This arrangement is necessary as it might often happen when the eudiometer was high out of the trough and nearly full of mercury, that the weight of it was sufficient to unwind the cat-gut on the axis *f*, and cause the tube *b*, to fall to its lowest position.

The general form of the mercury trough, which is made of gutta percha, is seen in Fig. 3, and Fig. 4 is a section of it through A B. The same letters apply to the same parts as seen in hoth figures. The sizes given are all inside measurement. The length from A to B is $9\frac{1}{2}$in. The thickness of the gutta percha sides is $\frac{1}{2}$in., and their height, as seen at B C and A D, Fig. 4, 5in. The ieft hand part of the trough, A E, is $3\frac{3}{8}$in. in diameter and 5in. deep. F represents the position of the pressure tuhe well, which is attached to the bottom of the trough, and G that of the well for the eudiometer. In Fig. 4, F H and G K represent these wells. The former is 15in. deep and 1in. in diameter, the latter is 29in. deep, and for the first 3in. after it leaves the trough it is $1\frac{9}{16}$in. in diameter; the lower part of it has the form shown in Fig. 5, the circular part being $1\frac{1}{16}$in. diameter, and the projecting part $\frac{1}{2}$in. wide and $\frac{1}{2}$in. long.

In the right-hand portion of the trough, from E to B (Fig. 3), the greater part of it is solid gutta percha to a height of 2in. from the bottom, as seen at B C, Fig. 4. The oblong figure in the middle shows the hole which is made there, and the canal joining what may he called the two troughs. L M is a small additional trough of the same height as the large one.

On referring to the sectional drawing, Fig. 4, the position and arrangement for the movements of the pressure tube and eudiometer will be easily seen. To the upper part of each of these tuhes the clamps before described are screwed, and the steel rods attached pass through, and can he held by, other clamps fastened to thick iron rods passing through the table. Into this round part of the trough fits a glass cylinder, ahout 27in. high, which is to he filled with water when the apparatus is in use. The cylinder is supported near the top by a ring fastened to one of the iron rods passing through the tahle, and the mercury in the trough prevents the escape of the water. The cylinder can thus be put on or taken off with great readiness. When the apparatus is in use, the mercury outside the cylinder stands at a height of about 1in. from the top of the trough. In the method of analysis adopted hy Bunsen, the reagents are introduced into the eudiometer. This procedure necessitates the use of only solid reagents, which can absorb the gases but slowly, and besides introducing a small error, namely, that of the gas always adhering to the surface of the reagent, it has the inconvenience, even with the greatest care, of dirtying the inside of the tube, and thus often rendering the reading off of the bulk of gas unsatisfactory. It is quite obvious that to remove these objections, a separate vessel must be used, into which the gas must he passed when the absorption of any of its constituents has to be effected. This is the lahoratory tube of Regnault and Frankland. The form of apparatus best suited for this transference of gas from the one tube to the other, is a point which has engaged much of our attention, and after making many experiments on the subject, we have adopted a process which is exceedingly satisfactory. By the means we are about to describe, the passage of the gas from the one tuhe to the other is complete, and easily effected; the apparatus is not fragile; and there is no stopcock or other source of leakage. Fig. 4 shows how this transference is effected. Down the centre of the eudiometer well, a glass tube, N, of about $\frac{3}{8}$in. diameter and very small bore, passes; it is bent round at the bottom, curving up in the small addition to the well, P (Fig. 5). When within about 5in. of the trough, the tuhe, N, bends, as shown in the figure, but afterwards, again hecoming straight, rises vertically into the right-hand part of the trough in the centre, Q (Figs. 3 and 4). Over this end of the tube is passed a vulcanised india ruhher pad with a short tuhe attached to it. This is shown in Fig. 6, and a section of it at R and Y (Fig. 4). The lower part of the india ruhher tube, Y, is bound with wire tightly on to the glass tuhe, N, so that the tuhe projects 3in. ahove the top of the circular pad, which is 3in. in diameter and $\frac{1}{4}$in. thick. It rests on an iron plate, S, which has a hole in the centre for the tube to pass through. This round pad and iron plate are supported by the solid gutta percha round the inside of the right-hand portion of the trough. The inside line, Fig. 3, shows how far it extends. The object of the india ruhher pad is to afford an elastic surface for pressing the lahoratory tuhe upon. The lahoratory tuhe, or rather laboratory vessel, we use, is shown in section at T, Fig. 4; it is round and made of rather thick glass. The height of it is 3in., so that the syphon tuhe, N, reaches exactly to the top of it. The end of the tuhe should he rounded, so that the middle part is higher than the outside. The lahoratory vessel is pressed down on the caoutchouc pad hy means of a flat iron har passing over the top of it. On each side of the trough there is an iron rod fastened into the tahle; a hole in one end of the flat bar allows it to pass over one of the rods; and a slot in the other end admits of its heing hrought so far, that the other rod is also in the centre of the flat har. A screw is turned on the top of the rods, so that hy means of a large nut, the bar may he pressed with very considerable force down on the top of the laboratory vessel. Instead, however, of the bar pressing directly on the top of the glass, it is hetter to have a small round iron frame roughly fitting on it, and having on the upper side a wedge-shaped piece of iron, on the thin edge of which the bar hefore described presses; hy this means the pressure is more equally distributed over the whole of the laboratory vessel. Fig. 8 represents this arrangement.

This laboratory vessel heing thus held firmly, we cau first expel the air from it hy allowing mercury to flow into it through a tube connected with a reservoir of mercury at the height of ahout $3\frac{1}{2}$ft. above it. This tube and reservoir are seen in Fig. 6; the tube forms part of the caoutchouc pad, and enters the wide part of the tube, Y, at right angles. When the pad is in its position in the trough, it passes through a hole in the side, and then through the small supplementary trough, L M (Fig. 3), passing out along the gutta percha tuhe U. A short piece of caoutchouc tuhing slipped on and hound to hoth these tubes serves to prevent the escape of the mercury from the trough. The end of this tube is fastened to the vessel, which forms the mercury reservoir. The reservoir is fixed to a wall, or other convenient support, above the trough. The use of the supplementary well, L M (Fig. 3), is to contain a clamp, hy which the flow of mercury from the reservoir can he regulated. This clamp is of very simple construction, and is shown in Fig. 7. It is placed in the trough, L M (Fig. 3), before passing the long tuhe through, so that the tuhe has to pass hetween the steel hars. After screwing the nut to a proper position on the rod, we can allow the mercury to flow from the reservoir, simply hy raising the rod out of the slot, and allowing the hars to separate, and stop it hy again hringing them together and replacing the rod in the slot. By this means we can very conveniently fill the laboratory vessel. The mercury flowing in at the hottom drives the air hefore it, and causes it to escape through the syphon tube, N (Fig. 4), and the mercury rising gradually to the highest part of the laboratory vessel, expels the last particle of air from it, and then fills the syphon tube. In this way the air is expelled at the commencement of an analysis from the laboratory vessel, and a gas, after it has heen treated with any reagent, is returned to the eudiometer for measurement. The reverse operation, the drawing the gas out of the eudiometer into the lahoratory vessel, is effected hy forming a vacuum in this vessel. To accomplish this, there is a small caoutchouc tuhe, V (Fig. 6), and V (Fig. 4), which is fastened to, or rather forms part of, the pad, R. The diameter of this tuhe is $\frac{1}{8}$iu. It passes through the pad at a distance of $\frac{3}{8}$in. from the large central tuhe. The length of the latter tuhe is 4in. It should be made of the best vulcanised india ruhber, and he from $\frac{3}{8}$ to $\frac{1}{2}$in. in diameter. To the end of the central tuhe is fastened a piece of thick harometer tuhing. The joining is best made by grinding the end of the barometer tube to a conical form, so that it may be forced up the hore of the caoutchouc tuhe. Before doing this, melted gutta percha should he dropped on the end of the glass tube, and after hinding the tuhe on as firmly as possihle with iron wire, more gutta percha may he melted round the end of it, so as to

render the joint as perfect as possible. The united length of these two tubes should be about 30in. The flow of mercury through the tubes is regulated by the following contrivance: at the lower end of the glass tube, a short piece of thick caoutchouc tube is bound firmly on and extends about $1\frac{1}{2}$in. beyond the end of the glass tube. A clamp for regulating the flow of mercury from the reservoir, similar in principle to the one before mentioned, passes across this piece of tubing, and, by tightly compressing it, prevents any mercury from passing through. It would, however, to say the least of it, be an exceedingly inconvenient arrangement if it were necessary for the operator to stoop down every time it was required to open or close this clamp. To avoid this, we use a strong pair of crucible tongs for a clamp. The only addition they require is a rod with a screw and nut fastened to one arm, and a slot made in the other, an arrangement precisely similar to that used with the other clamp (Fig. 7). The flexible tube is placed between the jaws of the tongs meant to clasp the crucible, and by opening or closing the other ends, we regulate the flow of the mercury. The tongs must, of course, be firmly held in one position, so that no strain shall come upon the suction tube. This is easily done by binding them to a support fixed in the floor. We have now all that is required for effecting the transfer of the gas between the eudiometer and the laboratory vessel. By opening the clamp compressing the tube from the reservoir, and retaining the clamp at the bottom of the suction tube closed, the gas is forced out of the laboratory vessel into the eudiometer; and by depressing the eudiometer until the top of it touches the end of the syphon tube, and then opening the clamp at the end of the suction-tube, the gas is forced along the syphon into the laboratory vessel. The end of the syphon tube, which is within the eudiometer, should be rounded as shown in Fig. 4; every particle of the gas can then be withdrawn from the tube.

It will readily be seen that this way of filling the eudiometer with mercury is not only simple, but accomplishes the end very satisfactorily; for the air being drawn out from the top of the eudiometer, the mercury rises gradually and regularly, the consequence of which is that no bubbles of air remain adhering to the tube, as they are apt to do when it is filled in the ordinary way. Owing to the elasticity of the syphon tube, and the upward pressure of the mercury, there is no fear of injuring the eudiometer by pressing it down till the syphon tube touches the top of it. In order that no bubble of gas may remain adhering to the syphon tube when the eudiometer is raised, the syphon should be struck once or twice with the end of the eudiometer as it is being lifted up.

While engaged in working out and perfecting this method of transfer of the gas, we have observed several interesting and important facts, which may be briefly mentioned. First, with regard to the imperfection of the joint made by pressing the laboratory vessel down upon the caoutchouc pad. It will be evident that by means of the screws on the rods, and the large nuts, the laboratory vessel can be pressed down with very considerable force. Besides this, the vessel is surrounded, both inside and out, with mercury to a height of one or two inches, but these precautions are not sufficient to prevent air passing into the laboratory vessel, when a vacuum is formed there. In the experiments made to test whether the vacuum remained perfect, or what amount of leakage took place, the flow of mercury through the syphon tube was prevented by slipping an india rubber cap over the end of the syphon, the eudiometer, of course, being removed. By this means it could be ascertained whether any leakage of air occurred after several hours, and even after several days. The mere pressing, however strongly, of the laboratory vessel down upon the pad, and surrounding it with mercury, were insufficient to retain a vacuum; in fact, the air can then enter with considerable rapidity, and is seen to bubble up into the laboratory vessel. The amount of leakage under these circumstances far exceeded what we had anticipated. It evidently arises from the want of contact between the mercury and the glass. A layer of air remains adhering to the glass both inside and out. When it is plunged into the mercury, there is thus a continuous chain of particles of air extending from the vacuum to the level of the mercury outside. The pressing of the vessel on the pad does not produce sufficiently close contact between the glass and caoutchouc to prevent the gradual movement of this layer of air, so that as the particles at one end of it pass up into the vacuum, others are drawn in from the surrounding air, and pass gradually along. By a very simple proceeding we are, however, able to prevent any appreciable error from leakage arising in this way; for it is only necessary to moisten the surface of the pad with water, or a dilute solution of corrosive sublimate, before covering it with mercury, and to fill with water the small hollow round the laboratory vessel produced by the expulsion of the mercury by the glass. When these precautions are taken, and other sources of error to which we shall immediately allude are eliminated, we are able to retain in the laboratory vessel an all but perfect vacuum; a vacuum, it is believed, far exceeding that obtained by any other means of this kind. In fact, if a vacuum be retained for twenty-four hours in the laboratory vessel, it will be found that the air which has entered, when reduced to atmospheric pressure, does not occupy a space much larger than that of a large pin's head; and it is probable that this small bubble of air has diffused through the water into the vacuum.

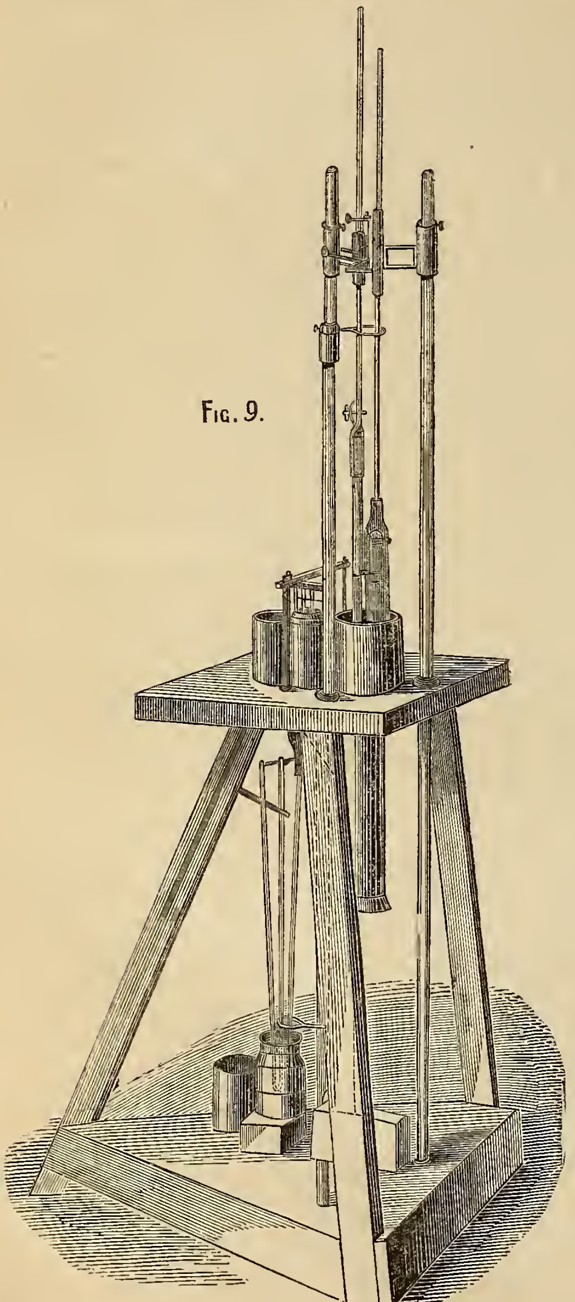
For some time after this method of passing the gas between the laboratory vessel and eudiometer as first adopted, we used the flexible tube and reservoir, both for increasing and diminishing the pressure on the laboratory vessel. To do this, it was only necessary to raise and lower the reservoir, which is easily done by means of a cord passing over a pulley; this would have rendered unnecessary the second or glass tube connected with the pad, and there would have been no occasion for the transfer of mercury from one vessel to another. We were, however, obliged to abandon this method, after making numerous experiments on the subject, for the simple reason that it was impossible to obtain any flexible tube perfectly air tight. Tubes of several kinds were made on purpose for these experiments; some were made with a small bore and composed of three or four layers of the best india rubber, very carefully joined, so as to form one thick tube, which was slightly vulcanised. Mr. Siemens was good enough to make us a tube of non-vulcanised india rubber, the joinings in which were united by his machine. Painting the tubes over with a solution of india rubber or gutta percha in benzol, while a vacuum existed in the laboratory vessel, was tried, but without success. With by far the greater number of the tubes used, the amount of leakage was very small, and when the apparatus is in use, the vacuum, or a near approach to it, instead of being retained for many hours, as was the case in these experiments, only continues for a very few seconds; still as the small quantities of air thus drawn in might accumulate in the tube, and then rise into the laboratory vessel, we consider it a sufficient reason for abandoning this plan for varying the pressure. Several methods were tried in which an intermediate vessel was used for collecting any air sucked into the tube; but this addition rendered the apparatus more complicated, and did not altogether give satisfactory results. With the glass tube adopted there is perfect freedom from leakage, and it adds but little to the size of the apparatus or to the trouble in manipulating. Fig. 9 represents a general view of the apparatus.

We now proceed to describe the method of using the apparatus and the precautions to be attended to. When filling the trough with mercury, care should be taken that air does not remain lodged under the caoutchouc pad; also, that the pad and neighbouring parts are well wetted, so as to prevent air being sucked in in the manner before described; in fact, it is best to fill the trough first with water and then pour in the mercury; this process also wets thoroughly the end of the small caoutchouc tube (Fig. 6), into which the glass one is fastened; if this is not attended to, a leakage might take place here in the same manner as at the laboratory vessel. The flexible tube connected with the mercury reservoir should also be well wetted before filling with mercury, and a little water always kept on the mercury in the reservoir; for if this is not done and the tube become dry, air cannot pass along it, and, in time, may find its way into the laboratory vessel. The suction tube is easily filled by first filling the laboratory vessel, and then opening the clamp at the bottom of the glass tube, and the clamp on the reservoir tube may also be opened at the same time if necessary to drive the last bubbles of air out. A wide-mouthed bottle, or any other convenient vessel of that kind may be used to catch the mercury as it flows from the suction tube, the end of which should always be kept below the surface of mercury. A convenient arrangement is to have a Wurtemberg syphon, one limb of which dips into this bottle, so as to retain the proper amount of mercury in it, and the other limb passes into a second vessel. The mercury flowing down the suction tube runs first into the bottle and then along the syphon into the other vessel. When this mercury is again required, the vessel containing it is removed from below the syphon and the mercury poured out of it into the upper reservoir. When the trough and tubes are properly filled, the mercury should be dried, the end of the syphon tube closed by the caoutchouc cap, and a vacuum formed in the laboratory vessel. This should be left for some hours, then the cap removed from the end of the syphon tube, and the laboratory vessel filled with mercury. This expels through the syphon tube all the air or water which has been sucked in. It may be necessary to repeat this process two or three times, in fact until, after leaving the vacuum for twelve or fourteen hours, it is found that nothing more than an exceedingly small bubble of air has entered. The apparatus should always be put to this very severe test before using it. When not in use it is well to keep the surface of the mercury wet.

The telescope or rather magnifying-glass, used in observing the height of the mercury, consists of a single convex glass set in a tube. The opening at which the eye is placed is small; this avoids any appreciable error from parallax. Within the tube are two fine platinum wires crossing in the centre at right angles. The straight brass rod about 2ft. 3in. long carrying the telescope, is fixed into a heavy stand provided with three levelling screws; this rests on the table which supports the mercury trough. The telescope is fastened to a short arm fixed to a brass tube 6in. long, which clasps the vertical rod, and to prevent this tube having any

lateral movement, the ends of it have a slit cut in them, so that they act as a spring, an arrangement similar to that used with the pressure tube and before described. A small ring provided with a screw passing through it also slides on the rod, so that it can be fixed to the rod at any point. The tube carrying the telescope rests on this ring, and is free to move in a horizontal plane. We can thus read off the height of the mercury in

Fig. 9.



the eudiometer and pressure tube. These tubes being close together, the angle through which the telescope has to move is small. The focal length of the magnifier used should be 6in. or 8in.

Let us, now, suppose a gas introduced into the eudiometer, and the cylinder filled with water; the volume of the gas is read off in the following way:—The pressure tube is raised or lowered by means of the clamp and rod attached to it, so as to bring the mercury in it about to the level of the lower edge of the horizontal marker which is to be used; next the eudiometer is adjusted in the same kind of way, so that the column of mercury in it is about the same height as that in the pressure tube; the telescope is then adjusted to the proper height; and directed to the mark behind the pressure tube, the mercury raised or lowered, as the case may be, by giving a screw movement either up or down to the glass tube, dipping into the mercury at the end of the trough. The tube is simply held by a clamp fastened into the table, and moves it with considerable friction. By this means, while looking through the telescope, the mercury in the pressure tube may, with the greatest accuracy, be made exactly to touch the bottom of the horizontal mark, which thus forms a tangent to the meniscus. The readings off are rendered much more certain, and are accomplished with much greater ease, if a screen of silver paper is placed at a short distance behind the apparatus, and in front of the source of light, which may be either an Argand-burner (the most convenient) or a window. The paper produces a diffused light over the whole apparatus, which renders the different parts, as seen through the telescope, very distinct. The two markers are made ⅜in. deep, so that they throw a shadow on the meniscus of mercury, thus rendering it quite black. The illuminated silver paper forms the back ground and gives the greatest possible distinctness to it. A slight touch now moves the telescope in the same horizontal plane, so that the eudiometer comes into view. The two markers, *l* and *m*, Fig. 1, it will be seen, project beyond the pressure tube, and reach to about half-way across the eudiometer, and the next operation is to bring the mercury meniscus in the eudiometer to such a height that it also exactly touches the lower edge of the marker. This raising or lowering of the mercury is effected by means of the fine adjustment before described attached to the upper clamp, which holds the eudiometer. The bringing of the mercury to the required height is as easy as in the former case; the only difference is that the marker, extending in this case only half way across the tube, leaves half of the meniscus illuminated, while the other half of the marker is quite dark, similar to the meniscus in the pressure tube. After adjusting the mercury in the eudiometer, so that the marker behind it is a tangent to the highest part of the meniscus, the telescope should again be turned to the pressure tube, in order to ascertain whether any appreciable alteration of the height of the mercury in it has taken place, by the raising or lowering of the eudiometer; and if so it is readjusted, which is but the work of a moment, the mercury in the eudiometer is again brought to the mark, and the height of the top of the meniscus read off on the graduated scale of the tube. Since the right hand half of the meniscus has no marker behind it, this is easily done, the diffused light behind rendering the graduation on the eudiometer particularly distinct. If the light behind should be so strong as to render the illuminated half of the meniscus somewhat indistinct, it is brought out with great sharpness by holding between it and the paper screen any opaque body, so as to throw its shadow on the meniscus, but without cutting off the light immediately above the meniscus. It is most convenient if the figures are written on the right hand side of the scale etched on the tube.

In a former part of this paper, we have described the clamp which holds the rod carrying the pressure tube, and have dwelt on the necessity of this rod being quite straight. It will now be evident that it is necessary for the accuracy of this method of measuring a gas, that the pressure tube should move up and down, so that the two markers attached to it always remain in a horizontal direction. The clamp sliding on the pillar passing through the table is always screwed to it exactly at the same place as shown by a mark on the rod. Before using the apparatus, it must be ascertained that the two markers are perfectly horizontal, and that they maintain this position when the pressure tube is raised or lowered to its fullest extent. The best method of doing this is to place immediately behind one of the markers a small glass vessel, with flat sides, containing mercury; then, on raising or lowering the tube, or by altering the amount of mercury in the vessel, the surface of the mercury may be brought close up to the lower edge of the marker, and by comparing the two throughout their whole length, especially when the distance between them is very small, it is at once seen whether the marker is horizontal. The observation may be made with the telescope, the paper screen and lamp being used. If this test shows the markers not to be horizontal, they are brought into that position by altering the level of the table, which should be a three-legged one. This is done either by screws fixed to the legs, or simply by introducing very thin wedges under the legs.

It will be obvious that there are several advantages in having the lower part of the pressure tube smaller than the upper part, for it then requires a smaller well to move freely up and down in, and less mercury to fill both tube and well. Care must be taken that the pressure tube does not at any time touch the sides of this well; for if it did, that would, of course, throw the markers out of their horizontal position. The tube, on being tapped, should always vibrate readily; this shows that it hangs free. Again, by diminishing the amount of mercury in the pressure tube as much as possible, we diminish the tendency it has to draw the iron pillar which supports it out of the vertical direction. When once properly adjusted, we do not find these markers liable to alter their position. All the readings are made with the gas saturated with moisture. A drop of water is intro-

duced into the eudiometer before filling it with mercury, and enough of it always remains adhering to the tube to saturate the gas, and even if the eudiometer has, in the course of an analysis, been filled two or three times with mercury. A very small quantity of water, as before mentioned, is also introduced into the pressure tube to saturate the standard volume of air. Any alteration in the temperature of the water surrounding the tubes during an analysis will not, as before pointed out, affect the accuracy of the results, provided that both tubes have undergone the same change of temperature. Since they are surrounded by some quantity of water, this condition is easily ensured by thoroughly agitating the water from time to time. This may conveniently be done by means of a wooden stirrer, having the form of a hoe.

To give an idea of the accuracy of this method, we may cite a few consecutive analyses of air freed from carbonic acid:—

1st Specimen of Air.

Air employed	202·83	Oxygen	21·002
After addition of hydrogen	363·84	Nitrogen	78·998
After explosion	236·04		100·000

Air employed	213·87	Oxygen	20·997
After addition of hydrogen	376·49	Nitrogen	79·003
After explosion	241·77		100·000

Air employed	252·42	Oxygen	20·991
After addition of hydrogen	419·58	Nitrogen	79·009
After explosion	260·62		100·000

2nd Specimen of Air.

Air employed	201·18	Air employed	211·10
After addition of hydrogen	353·34	After addition of hydrogen	375·37
After explosion	226·74	After explosion	242·59
Oxygen	20·976	Oxygen	20·966
Nitrogen	79·024	Nitrogen	79·034
	100·000		100·000

Air employed	194·88	Air employed	209·66
After addition of hydrogen	337·38	After addition of hydrogen	375·06
After explosion	214·83	After explosion	243·21
Oxygen	20.961	Oxygen	20·962
Nitrogen	79·039	Nitrogen	79·038
	100·000		100·000

It will be seen that in these analyses a comparatively small bulk of air was operated on, so that even a small absolute error would have led to a considerable alteration in the per centage composition of the air.

It now only remains for us to describe the method of applying the reagents. These are used generally in a plastic form; for instance, if a gas has to be subjected to the action of caustic potash, more or less of the inside of the laboratory vessel is covered with the reagent, by means of a wire brush. To obtain the potash of the proper degree of consistency, it is fused with a little water in a silver crucible. The small brush, made by binding a number of short pieces of thin iron wire together, is from time to time dipped into it, and the potash adhering to it spread on a piece of glass. The evaporation should be carried on till the trial-drop becomes solid on cooling, but still has a translucent appearance. The lamp is then immediately removed from under the crucible, and the potash is painted on the inside of the laboratory vessel round the middle, but not carried far up the conical part of it. Immediately after this operation is completed, the glass is placed in its position over the syphon tube, screwed down, and filled with mercury, the eudiometer having, of course, been previously raised out of the well and placed on one side, where it is supported by its clamp. The application of the reagent in this way has several advantages over any other method that has been proposed. If any air should adhere to the surface of the potash, the means exist of entirely removing it. This is done simply by forming a vacuum in the laboratory vessel; the air immediately diffuses into it, and is expelled through the syphon tube by allowing the mercury to flow into it from the reservoir. After the gas has been in contact with the potash, a vacuum is again formed, and the adhering gas, if any, passed into the eudiometer.

The caustic potash, when painted on in the proper condition, absorbs carbonic acid very rapidly, the absorption of a large amount of carbonic acid being completed in five minutes. The special object of not painting the top of the laboratory vessel with potash, is that in case a little of it should become liquid and float on the mercury, this will attach itself to the glass and not be carried into the syphon tube. In case, by any accident, potash should be carried into the syphon tube, it is easy to draw a little water through it, which will, of course, immediately remove it.

The following are two analyses made of a mixture of air and carbonic acid:—

Volume of gas taken	248·02	Volume of gas taken	230·63
After absorption by potash	201·80	After absorption by potash	187·56
After addition of hydrogen	356·80	After addition of hydrogen	331·11
After explosion	231·25	After explosion	214·17
Carbonic acid	18·64	Carbonic acid	18·68
Oxygen	16·87	Oxygen	16·90
Nitrogen	64·49	Nitrogen	64·42
	100·00		100·00

For the absorption of oxygen the simplest way of applying pyrogallate of potash, is to prepare the potash in the way before described, and then just before painting it on the laboratory vessel, some pyrogallic acid is added, and the mixture applied by means of the wire-brush.

The fuming sulphuric acid for the absorption of hydrocarbons is best applied by means of a coke ball. The gas is passed over into the laboratory vessel, the bar which presses it down taken off, and the coke ball introduced in the ordinary way; the absorption of the hydrocarbons takes place very rapidly. A potash-ball is afterwards introduced to absorb the acid vapours. As far as the form of this apparatus is concerned, it will be evident there is nothing to prevent the use of solid reagents in all cases if thought desirable.

The following are analyses of mixtures of known quantities of different gases:—

Volume of air employed	182·45
After addition of hydrogen	213·84
After addition of carbonic acid	257·98
After absorption by potash	213·84
After explosion	166·72

	Employed.	Found.
Carbonic acid	17·11	17·11
Hydrogen	12·17	12·17
Air	70·72	70·72
	100·00	100·00

Volume of nitrogen employed	95·76
After addition of carbonic acid	112·14
After addition of oxygen	132·73
After absorption by potash	116·27
After addition of hydrogen	187·70
After explosion	125·88

	Employed.	Found.
Carbonic acid	12·34	12·40
Oxygen	15·51	15·52
Nitrogen	72·15	72·08
	100·00	100·00

In the last analysis, only a very small quantity of gas was employed, and all the readings, except the one after adding hydrogen, were made by using the lower mark on the pressure tube, and thus expanding the gas to about double its volume at atmospheric pressure.

Oxygen or hydrogen is introduced into the eudiometer in the same way as in the ordinary process; it is only necessary to use a longer delivery tube, the end of which is introduced within the glass cylinder, by dipping it down the narrow canal joining the two circular troughs.

The best way of introducing into the apparatus the gas to be analysed, will depend upon the form of the vessel which contains it; if it should have a delivery tube, the gas can at once be bubbled up into the laboratory vessel, which has been previously filled with mercury; if it is contained in a tube, this is passed down over the syphon tube and the gas sucked out of it into the laboratory vessel. The tube containing the gas is easily brought over the syphon, either by removing the large glass cylinder, or by fastening a stick to the tube, which is done with a couple of caoutchouc rings, dipping the open end of it in a cup of mercury attached to a long rod and thus lowering it into the mercury trough. A third way is to bubble the gas at once into the eudiometer and then transfer it to the apparatus.

Sale of the Northfleet Dockyard.—On the 17th ult., this property was put up to public auction at the Guildhall Coffee-house. After a spirited competition, the dockyard was sold to Mr. Mare for £76,000. Fourteen lots of dwelling-houses, and public-houses, plots of freehold land, &c., were next submitted to public competition. The only portion of the estate left unsold, was the chalk mine, for which £16,000 was offered; but being below the reserved fund, it was withdrawn. Altogether, between £90,000 and £100,000 was realised.

THE ROYAL SOCIETY.

ON THE PROPERTIES OF SILICIC ACID AND OTHER ANALOGOUS COLLOIDAL SUBSTANCES.

By Thomas Graham, F.R.S., Master of the Mint.

The prevalent notions respecting solubility have been derived chiefly from observations on crystalline salts, and are very imperfectly applicable to the class of colloidal substances. Hydrated silicic acid, for instance, when in the soluble condition, is properly speaking a liquid body, like alcohol, miscible with water in all proportions. We have no degrees of solubility to speak of with respect to silicic acid, like the degrees of solubility of a salt, unless it be with reference to silicic acid in the gelatinous condition, which is usually looked upon as destitute of solubility. The jelly of silicic acid may be more or less rich in combined water, as it is first prepared, and it appears to be soluble in proportion to the extent of its hydration. A jelly containing 1 per cent. of silicic acid, gives with cold water a solution containing about 1 of silicic acid in 5,000 water; a jelly containing 5 per cent. of silicic acid, gives a solution containing about 1 part of acid in 10,000 water. A less hydrated jelly than the last mentioned is still less soluble; and finally, when the jelly is rendered anhydrous, it gives gummy-looking white masses, which appear to be absolutely insoluble, like the light dusty silicic acid obtained by drying a jelly charged with salts, in the ordinary analysis of a silicate.

The liquidity of silicic acid is only affected by a change, which is permanent (namely, coagulation or pectization), by which the acid is converted into the gelatinous or pectous form, and loses its miscibility with water. The liquidity is permanent in proportion to the degree of dilution of silicic acid, and appears to be favoured by a low temperature. It is opposed, on the contrary, by concentration, and by elevation of temperature. A liquid silicic acid of 10 or 12 per cent. pectizes spontaneously in a few hours at the ordinary temperature, and immediately when heated. A liquid of 5 per cent. may be preserved for five or six days; a liquid of 2 per cent. for two or three months; and a liquid of 1 per cent. has not pectized after two years. Dilute solutions of 0·1 per cent. or less are no doubt practically unalterable by time, and hence the possibility of soluble silicic acid existing in nature. I may add, however, that no solution, weak or strong, of silicic acid in water has shown any disposition to deposit *crystals*, but always appears on drying as a colloidal glassy hyalite. The formation of quartz crystals at a low temperature, of so frequent occurrence in nature, remains still a mystery. I can only imagine that such crystals are formed at an inconceivably slow rate, and from solutions of silicic acid which are extremely dilute. Dilution no doubt weakens the colloidal character of substances, and may therefore allow their crystallising tendency to gain ground and develop itself, particularly where the crystal once formed is completely insoluble, as with quartz.

The pectization of liquid silicic acid is expedited by contact with solid matter in the form of powder. By contact with pounded graphite, which is chemically inactive, the pectization of a 5 per cent. silicic acid is brought about in an hour or two, and that of a 2 per cent. silicic acid in two days. A rise of temperature of 1°·1 C. was observed during the formation of the 5 per cent. jelly.

The ultimate pectization of silicic acid is preceded by a gradual thickening in the liquid itself. The flow of liquid colloids through a capillary tube is always slow compared with the flow of crystalloid solutions, so that a liquid-transpiration-tube may be employed as a colloidoscope. With a colloidal liquid alterable in viscosity, such as silicic acid, the increased resistance to passage through the colloidoscope is obvious from day to day. Just before gelatinising, silicic acid flows like an oil.

A dominating quality of colloids is the tendency of their particles to adhere, aggregate, and contract. This idio-attraction is obvious in the gradual thickening of the liquid, and when it advances leads to pectization. In the jelly itself, the specific contraction in question, or *synæresis*, still proceeds, causing separation of water, with the division into a clot and serum; and ending in the production of a hard stony mass, of vitreous structure, which may be anhydrous, or nearly so, when the water is allowed to escape by evaporation. The intense synæresis of isinglass dried in a glass dish over sulphuric acid *in vacuo*, enables the contracting gelatin to tear up the surface of the glass. Glass itself is a colloid, and the adhesion of colloid to colloid appears to be more powerful than that of colloid to crystalloid. The gelatin, when dried in the manner described upon plates of calcspar and mica, did not adhere to the crystalline surface, but detached itself on drying. Polished plates of glass must not be left in contact, as is well known, owing to the risk of permanent adhesion between their surfaces. The adhesion of broken masses of glacial phosphoric acid to each other is an old illustration of colloidal synæresis.

Bearing in mind that the colloidal phasis of matter is the result of a peculiar attraction and aggregation of molecules, properties never entirely absent from matter, but greatly more developed in some substances than in others, it is not surprising that colloidal characters spread on both sides into the liquid and solid conditions. These characters appear in the viscidity of liquids, and in the softness and adhesiveness of certain crystalline substances. Metaphosphate of soda, after fusion by heat, is a true glass or colloid; but when this glass is maintained for a few minutes at a temperature some degrees under its point of fusion, the glass assumes a crystalline structure without losing its transparency. Notwithstanding this change, the low diffusibility of the salt is preserved, with other characters of a colloid. Water in the form of ice has already been represented as a similar intermediate form, both colloid and crystalline, and in the first character adhesive and capable of reunion or "regelation."

It is unnecessary to return here to the fact of the ready pectization of liquid silicic acid by alkaline salts, including some of very sparing solubility, such as carbonate of lime, beyond stating that the presence of carbonate of lime in water was observed to be incompatible with the co-existence of soluble silicic acid, till the proportion of the latter was reduced to nearly 1 to 10,000 water.

Certain liquid substances differ from the salts in exercising little or no pectizing influence upon liquid silicic acid. But, on the other hand, none of the liquids now referred to appear to conduce to the preservation of the fluidity of the colloid, at least not more than the addition of water would do. Among these inactive diluents of silicic acid are found hydrochloric, nitric, acetic, and tartaric acids, syrup of sugar, glycerine, and alcohol. But all the liquid substances named, and many others, appear to possess an important relation to silicic acid, of a very different nature from the pectizing action of salts. They are capable of displacing the combined water of the silicic acid hydrate, whether that hydrate is in the liquid or gelatinous condition, and give new substitution products.

A liquid compound of alcohol and silicic acid is obtained by adding alcohol to aqueous silicic acid, and then employing proper means to withdraw the water from the mixture. For that purpose the mixture contained in a cup may be placed over dry carbonate of potash or quicklime, within the receiver of an air-pump. Or a dialysing bag of parchment-paper containing the mixed alcohol and silicic acid may be suspended in a jar of alcohol; the water diffuses away, leaving in the bag a liquid composed of alcohol and silicic acid only. A point to be attended to is, that the silicic acid should never be allowed to form more than 1 per cent. of the alcoholic solution, otherwise it may gelatinise during the experiment. If I may be allowed to distinguish the liquid and gelatinous hydrates of silicic acid by the irregularly formed terms of hydrosol and hydrogel of silicic acid, the two corresponding alcoholic bodies now introduced may be named the alcosol and alcogel of silicic acid.

The alcosol of silicic acid, containing 1 per cent. of the latter is a colourless liquid, not precipitated by water or salts, nor by contact with insoluble powders, probably from the small proportion of silicic acid present in solution. It may be boiled and evaporated without change, but is gelatinised by a slight concentration. The alcohol is retained less strongly in the alcosol of silicic acid than water is in the hydrosol, but with the same varying force, a small portion of the alcohol being held so strongly as to char when the resulting jelly is rapidly distilled at a high temperature. Not a trace of silicic ether is found in any compound of this class. The jelly burns readily in the air, leaving the whole silicic acid in the form of a white ash.

The alcogel, or solid compound, is readily prepared by placing masses of gelatinous silicic acid, containing 8 or 10 per cent. of the dry acid, in absolute alcohol, and changing the latter repeatedly till the water of the hydrogel is fully replaced by alcohol. The alcogel is generally slightly opalescent, and is similar in aspect to the hydrogel, preserving very nearly its original bulk. The following is the composition of an alcogel carefully prepared from a hydrogel which contained 9·35 per cent. of silicic acid:—

Alcohol	88·13
Water	0·23
Silicic acid	11·64
	100·00

Placed in water, the alcogel is gradually decomposed—alcohol diffusing out and water entering instead, so that a hydrogel is reproduced.

Further, the alcogel may be made the starting-point in the formation of a great variety of other substitution jellies of analogous constitution, the only condition required appearing to be that the new liquid and alcohol should be intermiscible, that is, interdiffusible bodies. Compounds of ether, benzole, and bisulphide of carbon have thus been produced. Again, from etherogel, another series of silicic acid jellies may be derived, containing fluids soluble in ether, such as the fixed oils.

The preparation of the glycerine compound of silicic acid is facilitated by the comparative fixity of that liquid. When hydrated silicic acid is first steeped in glycerine, and then boiled in the same liquid, water distils over, without any change in the appearance of the jelly, except that when formerly opalescent it becomes now entirely colourless, and ceases to be visible when covered by the liquid. But a portion of the silicic acid is dissolved, and a glycerosol is produced at the same time as the glycerine jelly. A glycerogel prepared from a hydrate containing 9·35 per cent. of silicic acid, was found by a combustion analysis to be composed of

Glycerine	87·44
Water	3·78
Silicic acid	8·95
	100·17

The glycerogel has somewhat less bulk than the original hydrogel. When a glycerine jelly is distilled by heat, it does not fuse, but the whole of the glycerine comes over, with a slight amount of decomposition towards the end of the process.

The compound of sulphuric acid, sulphagel, is also interesting from the facility of its formation, and the complete manner in which the water of the original hydrogel is removed. A mass of hydrated silicic acid may be preserved unbroken if it is first placed in sulphuric acid diluted with two or three volumes of water, and then transferred gradually to stronger acids, till at last it is placed in concentrated oil of vitriol. The sulphagel sinks in the latter fluid, and may be distilled with an excess of it for hours without losing its transparency or gelatinous character. It is always somewhat less in bulk than the primary hydrogel, but not more, to the eye, than one-fifth or one-sixth part of the original volume. This sulphagel is transparent and colorless. When a sulphagel is heated strongly in an open vessel, the last portions of the monohydrated sulphuric acid in combination are found to require a higher temperature for their expulsion than the boiling-point of the acid. The whole silicic acid remains behind, forming a white, opaque, porous mass, like pumice. A sulphagel placed in water is soon decomposed, and the original hydrogel reproduced. No permanent compound of sulphuric and silicic acids, of the nature of a salt, appears to be formed in any circumstances. A sulphagel

placed in alcohol gives ultimately a pure alcogel. Similar jellies of silicic acid may readily be formed with the monohydrates of nitric, acetic, and formic acids, and are all perfectly transparent.

The production of the compounds of silicic acid now described indicates the possession of a wider range of affinity by a colloid than could well be anticipated. The organic colloids are no doubt invested with similar wide powers of combination, which may become of interest to the physiologist. The capacity of a mass of gelatinous silicic acid to assume alcohol, or even oleine, in the place of water of combination, without disintegration or alteration of form, may perhaps afford a clue to the penetration of the albumenous matter of membrane by fatty and other insoluble bodies, which seems to occur in the digestion of food. Still more remarkable and suggestive are the *fluid* compounds of silicic acid. The fluid alcohol-compound favours the possibility of the existence of a compound of the colloid albumen with oleine, soluble also and capable of circulating with the blood.

The feebleness of the force which holds together two substances belonging to different physical classes, one being a colloid and the other a crystalloid, is a subject deserving notice. When such a compound is placed in a fluid, the superior diffusive energy of the crystalloid may cause its separation from the colloid. Thus, of hydrated silicic acid, the combined water (a crystalloid) leaves the acid (a colloid) to diffuse into alcohol; and if the alcohol be repeatedly changed, the entire water is thus removed, alcohol (another crystalloid) at the same time taking the place of water in combination with the silicic acid. The liquid in excess (here the alcohol) gains entire possession of the silicic acid. The process is reversed if an alcogel be placed in a considerable volume of water. Then alcohol separates from combination, in consequence of the opportunity it possesses to diffuse into water; and water, which is now the liquid present in excess, recovers possession of the silicic acid. Such changes illustrate the predominating influence of mass.

Even the compounds of silicic acid with alkalies yield to the decomposing force of diffusion. The compound of silicic acid with 1 or 2 per cent. of soda is a colloidal solution, and, when placed in a dialyzer over water *in vacuo* to exclude carbonic acid, suffers gradual decomposition. The soda diffuses off slowly in the caustic state, and gives the usual brown oxide of silver when tested with the nitrate of that base.

The pectization of liquid silicic acid and many other liquid colloids is effected by contact with minute quantities of salts in a way which is not understood. On the other hand, the gelatinous acid may again be liquefied and have its energy restored by contact with a very moderate amount of alkali. The latter change is gradual—1 part of caustic soda, dissolved in 10,000 water, liquefying 200 parts of silicic acid (estimated dry) in 60 minutes at 100° C. Gelatinous stannic acid also is easily liquefied by a small proportion of alkali, even at the ordinary temperature. The alkali, too, after liquefying the gelatinous colloid, may be separated again from it by diffusion into water upon a dialyzer. The solution of these colloids in such circumstances may be looked upon as analogous to the solution of insoluble organic colloids witnessed in animal digestion, with the difference that the solvent fluid here is not acid but alkaline. Liquid silicic acid may be represented as the "pepton" of gelatinous silicic acid, and the liquefaction of the latter by a trace of alkali may be spoken of as the peptisation of the jelly. The pure jellies of alumina, peroxide of iron, and titanic acid, prepared by dialysis, are assimilated more closely to albumen, being peptised by minute quantities of hydrochloric acid.

Liquid Stannic and Metastannic Acids.—Liquid stannic acid is prepared by dialyzing the bichloride of tin with an addition of alkali, or by dialyzing the stannate of soda with an addition of hydrochloric acid. In both cases a jelly is first formed on the dialyzer; but, as the salts diffuse away, the jelly is again peptised by the small proportion of free alkali remaining; the alkali itself may be removed by continued diffusion, a drop or two of the tincture of iodine facilitating the separation. The liquid stannic acid is converted on heating it into liquid metastannic acid. Both liquid acids are remarkable for the facility with which they are pectised by a minute addition of hydrochloric acid, as well as by salts.

Liquid Titanic Acid is prepared by dissolving gelatinous titanic acid in a small quantity of hydrychloric acid, without heat, and placing the liquid upon a dialyzer for several days. The liquid must not contain more than 1 per cent. of titanic acid, otherwise it spontaneously gelatinises, but it appears more stable when dilute. Both titanic and the two stannic acids afford the same classes of compounds with alcohol, &c., as are obtained with silicic acid.

Liquid Tungstic Acid.—The obscurity which has so long hung over tungstic acid is removed by a dialytic examination. It is, in fact, a remarkable colloid, of which the pectous form alone has hitherto been known. Liquid tungstic acid is prepared by adding dilute hydrochloric acid carefully to a 5 per cent. solution of tungstate of soda, in sufficient proportion to neutralize the alkali, and then placing the resulting liquid on a dialyzer. In about three days the acid is found pure, with the loss of about 20 per cent., the salts having diffused entirely away. It is remarkable that the *purified* acid is not pectised by acids or salts even at the boiling temperature. Evaporated to dryness, it forms vitreous scales, like gum or gelatin, which sometimes adhere so strongly to the surface of the evaporating dish as to detach portions of it. It may be heated to 200° C. without losing its solubility or passing into the pectous state, but at a temperature near redness it undergoes a molecular change, losing at the same time 2·42 per cent of water. When water is added to unchanged tungstic acid it becomes pasty and adhesive like gum, and it forms a liquid with about one-fourth its weight of water, which is so dense as to float glass. The solution effervesces with carbonate of soda, and tungstic acid is evidently associated with silicic and molybdic acids. The taste of tungstic acid dissolved in water is not metallic or acid, but rather bitter and astringent. Solutions of tungstic acid containing 5, 20, 50, 66·5, and 79·8 per cent. of dry acid, possess the following densities at 19°: 1·0475, 1·2168, 1·8001, 2·396, and 3·243. Evaporated *in vacuo* liquid tungstic acid is colourless, but becomes green in air from the deoxidating action of organic matter. Liquid silicic acid is protected from pectising when mixed with tungstic acid; a circumstance probably connected with the formation of the double compounds of these acids which M. Marignac has lately described.

Molybdic Acid has hitherto been known (like tungstic acid) only in the insoluble form. Crystallised molybdate of soda dissolved in water is decomposed by the gradual addition of hydrochloric acid in excess, without any immediate precipitation. The acid liquid thrown upon a dialyzer may gelatinise after a few hours, but again liquefies spontaneously, when the salts diffuse away. After a diffusion of three days, about 60 per cent. of the molybdic acid remains behind in a pure condition. The solution of pure molybdic acid is yellow, astringent to the taste, acid to test-paper, and possesses much stability. The acid may be dried at 100°, and then heated to 200° without losing its solubility. Soluble molybdic acid has the same gummy aspect as soluble tungstic acid, and deliquesces slightly when exposed to damp air. Both acids lose their colloidality when digested with soda for a short time, and give a variety of crystallisable salts.

RESEARCHES ON THE COLOURING-MATTERS DERIVED FROM COAL-TAR.—III. DIPHENYLAMINE.

By A. W. HOFMANN, LL.D., F.R.S.

In the course of last year* I published an account of some experiments upon the composition of the blue colouring-matter discovered by MM. Girard and De Laire when studying the action of aniline upon rosaniline.

These experiments had established a simple relation between aniline-red and aniline-blue, the latter exhibiting the composition of triphenylated rosaniline—

$$C_{20}\,H_{19}\,N_3,\ H_2\,O + 3\left.\begin{matrix}C_6\,H_5\\ H_2\end{matrix}\right\}N = 3H_3N + C_{20}\,\begin{matrix}H_{16}\\ (C_6H_5)_3\end{matrix}\,N_3,\ H_2\,O.$$

The composition of aniline-blue has since been also investigated by M. Schiff†, who, in a paper published shortly after my first communication upon this subject, attributes to this compound a formula differing from the expression at which I had arrived. According to M. Schiff, aniline-blue is not a *triamine*, as I had found, but a *tetramine*, which may be looked upon as a combination of rosaniline with tryphenylamine,

$$C_{38}\,H_{34}\,N_4,\ H_2O = C_{20}\,H_{19}\,N_3,\ H_2O + (C_6\,H_5)_3\,N.$$

This formula is less simple than the one I had given; it attributes to aniline-blue a constitution not supported by analogy, and involves the necessity of assuming, for the formation of this substance, a reaction which ceases to be a simple process of substitution.

M. Schiff's formula is given as the result of an unfinished inquiry, and the author himself appears to have but limited confidence in its correctness. Nevertheless, the publication of his note imposed upon me the duty of confirming by new experiments the result of my former researches upon this subject.

The material used in these new experiments was likewise furnished to me by Mr. Nicholson; it had been taken from the product of an operation perfectly different from the one which had supplied the first specimen. In the following synopsis the experimental numbers of the former analyses are marked (*a*), in contradistinction to those (*b*) recently performed.

Free Base.

$C_{38}\,H_{36}\,N_4O$ (Schiff).			$C_{38}\,H_{33}\,N_3O$ (Hofmann).		
C_{38}	456	80·85	C_{38}	456	83·36
H_{36}	36	6·38	H_{33}	33	6·03
N_4	56	9·93	N_3	42	7·69
O	16	2·84	O	16	2·92
	564	100·00		547	100·00

Analyses (Hofmann).

	a.		*b.*	
Carbon	83·81	83·89	83·13	—
Hydrogen	6·20	6·18	6·04	—
Nitrogen	—	—	—	8·16

Chloride.

$C_{38}\,H_{35}\,N_4\,Cl$ (Schiff).			$C_{38}\,H_{32}\,N_3\,Cl$ (Hofmann).		
C_{38}	456	78·28	C_{38}	456	80·64
H_{35}	35	6·01	H_{32}	32	5·66
N_4	56	9·61	N_3	42	7·43
Cl	35·5	6.10	Cl	35·5	6·27
	582·5	100·00		565·5	100·00

Analyses (Hofmann).

	a.				*b.*		
Carbon	80·58	80·57	—	—	80·68	—	—
Hydrogen	5·70	5·71	—	—	5·67	—	—
Nitrogen	—	—	—	—	—	7·76	—
Chlorine	—	—	6·10	6·73	—	—	6·12

* Proceedings of the Royal Society, vol xii., p. 578; vol xiii., p. 9.
† Comptes Rendus, lvi. 1234.

Bromide.

	$C_{38}H_{35}N_4Br$ (Schiff).			$C_{38}H_{32}N_3Br$ (Hofmann).	
C_{38}	456	72·73	C_{38}	456	74·75
H_{35}	35	5·58	H_{32}	32	5·25
N_4	56	8·93	N_3	42	6·88
Br	80	12·76	Br	80	13·12
	627	100·00		610	100·00

Analyses (Hofmann).

	a.		
Carbon	74·60	—	—
Hydrogen	5·37	—	—
Nitrogen	—	7·59	—
Bromine	—	—	12·59

Nitrate.

	$C_{38}H_{35}N_5O_3$ (Schiff).			$C_{38}H_{32}N_4O_3$ (Hofmann).	
C_{38}	456	74·88	C_{38}	456	77·03
H_{35}	35	5.75	H_{32}	32	5·40
N_5	70	11·49	N_4	56	9·46
O_3	48	7·88	O_3	48	8·11
	609	100·00		592	100·00

Analyses (Hofmann).

Carbon	77·55	77·17
Hydrogen	5·36	5·41

Triphenylic Leucaniline.

	$C_{38}H_{33}N_3$		
C_{38}	456	85·88	85·75
H_{33}	33	6·21	6·15
N_3	42	7·91	—
	531	100·00	

The preceding analyses appear to establish beyond a doubt the composition of aniline-blue; and I do not hesitate to maintain the formula originally established by me as the true expression of the constitution of this compound.

The resumption of this inquiry has led me to some observations which afford an additional support of the composition of aniline-blue.

Rosaniline, when submitted to dry distillation, undergoes an irregular decomposition. Ammonia is evolved, a large amount of liquid bases (from 40 to 50 per cent.) passes over, and a porous mass of charcoal remains in the retort. The principal constituent of the liquid product is aniline.

Ethyl-rosaniline, the commercial aniline-violet, already manufactured on a large scale by Messrs. Simpson, Maule, and Nicholson, when distilled, exhibits similar phenomena. There is no difficulty in separating from the liquid product an appreciable amount of ethylaniline, the presence of which has been established by the examination of the platinum-salt.

The relation existing between aniline-violet, obtained by the action of iodide of ethyl, and aniline-red, cannot possibly be doubtful. Now, since analysis points out similar relations between aniline-blue and aniline-red, it became perfectly legitimate to anticipate, among the products of distillation of aniline-blue, *i.e.*, of phenylated rosaniline, the presence of phenylated aniline, or diphenylamine, a substance which chemists had often, but vainly, endeavoured to prepare. Experiment has verified this anticipation.

Some weeks ago my friend, M. Charles Girard, Director of the Works of the Fuchsine Company at Lyons, had the kindness to transmit to me for examination some basic oils of high boiling point which he had obtained by the destructive distillation of a considerable quantity of aniline-blue. The product of distillation which he forwarded to me was brown and viscid. When rectified, it furnished a slightly coloured liquid; at 300° the thermometer indicated the distillation of a definite compound.

The distillate which had passed between 280° and 300° solidified on addition of hydrochloric acid, a chloride difficultly soluble (more especially in concentrated hydrochloric acid) being formed. By washing with alcohol, and ultimately by crystallisation from this liquid, the chloride was obtained in a state of purity. When treated with ammonia, it furnished colourless oily drops, which, after a few moments, solidified to a white crystalline mass.

The crystals thus obtained possess a peculiar flower-like odour; their taste is aromatic, and afterwards burning. At 45° they fuse to a yellowish oil, distilling constantly, and without alteration, at 312° (corr.). They are almost insoluble in water, easily soluble in alcohol and ether. Neither in aqueous nor in alcoholic solution has the substance any alkaline reaction. When brought into contact with concentrated acids, the crystals are converted into the corresponding salts, which are remarkable for their instability. On the addition of water, the base separates in oily drops, rapidly solidifying to crystals. The chloride, when washed with water, loses every trace of hydrochloric acid.

The analysis of the base has led to the formula

$$C_{12}H_{11}N.$$

The composition of the chloride, which crystallises from alcohol in concentrically grouped needles, assuming a bluish tint by contact with the air is

$$C_{12}H_{11}N, HCl.$$

I do not believe that I am deceived in considering this compound as diphenylamine,

$$C_{12}H_{11}N = \left.\begin{matrix} C_6H_5 \\ C_6H_5 \\ H \end{matrix}\right\} N.$$

It deserves, however, to be stated that the strict experimental demonstration of this mode of viewing the compound is still wanting, the ethylation of the substance presenting difficulties that I have not yet been able to overcome. I regret this gap, since the experience acquired in the study of xenylamine, isomeric with diphenylamine,

$$C_{12}H_{11}N = \left.\begin{matrix} C_{12}H_9 \\ H \\ H \end{matrix}\right\} N = \left.\begin{matrix} C_6H_5 \\ C_6H_5 \\ H \end{matrix}\right\} N,$$

and which for several weeks I regarded as the secondary phenyl-base, points out the necessity of consistently carrying out the process of ethylation in the examination of bases of this kind.

Diphenylamine exhibits a peculiar reaction, which, while it appears to reveal its relation to the colour-generating aniline, enables us to recognise the presence of the new base. In contact with concentrated nitric acid, diphenylamine, as well as its salts, assumes at once a magnificent blue colouration. The reaction succeeds best by pouring concentrated hydrochloric acid upon a crystal of the base, and then adding the nitric acid drop by drop. Immediately the whole liquid becomes intensely indigo-blue. Minute quantities of diphenylamine may in this manner be readily traced. I have thus been enabled to ascertain the presence of this body, or, at all events, of a substance exhibiting this particular reaction, in the products of distillation of rosaniline, leucaniline, and even of melaniline. The last experiment deserves particularly to be noticed, since it affords the general method for the production of the secondary aromatic monamines, which was hitherto wanting.

The substance possessing the blue colour is formed also by the action of other oxidising agents. On adding chloride of platinum to a solution of the chloride, the liquid at once assumes a deep-blue colour. Only, from very concentrated solutions, a platinum-salt is deposited exhibiting an undesirably blue tint.

When a mixture of diphenylamine and toluidine is submitted to one of the processes (treatment with chloride of mercury or arsenic acid) which, if phenylamine and toluidine had been employed, would have furnished rosaniline, a mass is formed which dissolves in alcohol with a magnificent blue colouration, and possesses the characters of a true colouring-matter.

An alcoholic solution of diphenylamine furnishes, on addition of bromine, a yellow crystalline precipitate, difficultly soluble in cold alcohol, but crystallising from boiling alcohol in beautiful needles of a satiny lustre. According to analysis, they contain

$$C_{12}H_7Br_4N,$$

a formula which renders the grouping

$$\left.\begin{matrix} C_6H_3Br_2 \\ C_6H_3Br_2 \\ H \end{matrix}\right\} N$$

probable.

A mixture of diphenylamine and chloride of benzoyl, when heated, furnishes a thick oil, which solidifies on cooling. Washed with water and alkali, and recrystallised from boiling alcohol, in which it dissolves with difficulty, the new compound is obtained in beautiful white needles. Analysis has confirmed the theoretical anticipation,

$$C_{19}H_{15}NO = \left.\begin{matrix} C_6H_5 \\ C_6H_5 \\ C_7H_5O \end{matrix}\right\} N.$$

This substance has become the starting-point of some experiments which I shall here briefly mention, but to which I intend to return hereafter. On addition of ordinary concentrated nitric acid, the benzoyl-compound liquefies and dissolves. From this solution, water precipitates a light-yellow crystalline compound,

$$C_{19}H_{14}N_2O_3 = \left.\begin{matrix} C_6H_5 \\ C_6H_4(NO_2) \\ C_7H_5O \end{matrix}\right\} N,$$

which dissolves in alcoholic soda with a scarlet colour, splitting on ebullition into benzoic acid and reddish-yellow needles of nitro-diphenylamine,

$$C_{12}H_{10}N_2O_2 = \left.\begin{matrix} C_6H_5 \\ C_6H_4(NO_2) \\ H \end{matrix}\right\} N.$$

If, instead of ordinary nitric acid, a large excess of the strongest fuming nitric acid be employed, the solution deposits, on addition of water, a crystalline compound of a somewhat deeper yellow colour, containing probably

$$C_{19}H_{13}N_3O_5 = \left.\begin{matrix} C_6H_4(NO_2) \\ C_6H_4(NO_2) \\ C_7H_5O \end{matrix}\right\} N.$$

This substance dissolves in alcoholic soda with a most magnificent crimson colour. Addition of water to the boiling liquid furnishes a yellow crystalline deposit, benzoate (?) of sodium remaining in solution.

The yellow powder is dinitro-diphenylamine. From boiling alcohol, it crystallises in reddish needles, exhibiting a bluish metallic lustre. The analysis of the compound has led to the formula

$$C_{12}H_9N_3O_4 = \left.\begin{matrix} C_6H_4(NO_2) \\ C_6H_4(NO_2) \\ H \end{matrix}\right\} N.$$

The chemical history of these compounds will be the subject of a special communication.

MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The ordinary monthly meeting of this Association was held on July 26th, 1864, when the chief engineer presented his report, of which the following is an abstract:—

"During the last month 218 engines have been examined, and 327 boilers, 14 of the latter being examined specially, and 6 of them tested with hydraulic pressure. Of the boiler examinations, 259 have been external, 11 internal, and 57 thorough. In the boilers examined, 173 defects have been discovered, 3 of them being dangerous. Details of these will be found in the following tabular statement:—

FROM JUNE 25TH, 1864, TO JULY 22ND, 1864, INCLUSIVE.

DESCRIPTION.	Number of Cases met with		
	Dangerous.	Ordinary.	Total.
DEFECTS IN BOILER.			
Furnaces out of shape	...	5	5
Fracture	1	4	5
Blistered Plates	...	6	6
Corrosion—Internal	...	5	5
Do. External	...	10	10
Grooving—Internal	...	4	4
Do. External	...	...	...
Total number of Defects in Boiler	1	34	35
DEFECTIVE FITTINGS.			
Feed Apparatus Out of Order	1	...	1
Water Gauges ditto	...	8	8
Blow Out Apparatus ditto	...	16	16
Fusible Plugs ditto	...	...	...
Safety Valves ditto	...	3	3
Pressure Gauges ditto	...	4	4
Total number of Defective Fittings	1	31	32
OMISSIONS.			
Boilers without Glass Water Gauges	...	3	3
Ditto Pressure Gauges	...	...	...
Ditto Blow Out Apparatus	...	51	51
Ditto Feed Back Pressure Valves	...	50	50
Total Number of Omissions	...	104	104
Cases of Over Pressure	1	...	1
Cases of Deficiency of Water	...	1	1
Gross Total	3	170	173

"EXPLOSIONS.

"No. 17 explosion occurred during last month, and by it three persons were killed and two others injured, one of them very seriously.

"The boiler in question was the centre one of a series of three, working at a colliery, all of them being of plain cylindrical egg-ended construction, externally-fired, and each set with a flash flue. The length of the boiler was 37ft., its diameter 6ft. 6in., and the thickness of the plates from three-eighths to seven-sixteenths of an inch; while the safety-valve was loaded to a pressure of 40lb. per square inch, which was by no means excessive for a boiler of such dimensions. It rent, as is so usual in these cases, through the line of rivet holes at one of the transverse seams, starting, in the first instance, at the bottom, and then running round the entire shell, and thus separating it into two pieces. In this instance the rupture occurred about mid-way in the length of the boiler, the firing end containing five widths or belts of plate, and being about 17ft. 6in. long, and the chimney end containing six widths of plate, and being about 19ft. 6in. long. These portions of the boiler flew in opposite directions, the firing end to a distance of about 170 yards from its original seat, and the chimney end about 130 yards, or upwards of one-sixth of a mile apart. In addition to this, the two sister boilers were dislodged, and one of them thrown to a distance of nearly 30 yards; while the chimney was knocked down, the boiler-shed demolished, and the engine-house unroofed. One of these boilers was at work with its steam up at the time, and that it escaped explosion under the treatment it received is surprising; while the fact of its having been thrown over as it was, clearly shows how it is that the explosion of one such boiler so frequently leads to that of all those surrounding it.

"The greater portion of the water, with which the exploded boiler was fed, was drawn from the workings of the pit, and was of a sedimentary character; while it was pumped into the boiler cold, and, in addition, the firing appears to have been severe. These are trying conditions for an externally-fired boiler, and it is not, therefore, surprising that the seams of rivets, over the fire, gave way repeatedly; indeed, such frequent repair was needed, that as much as £200 as the proprietor stated at the inquest, had been expended in consequence on two of the boilers, though only three years old, the third one being new, and not as yet set to work. Only a few months ago the exploded boiler had been newly bottomed at the furnace end for about half its length, five of the belts or widths of plate at the part over the fire having been renewed, and it was where the new work joined on to the old, that the rent commenced; the rent running from rivet hole to rivet hole through the old plate which formed the inner overlap, while the new work did not give way. This rent did not run round the entire seam of rivets instantaneously, but opened for a short distance at the bottom in the first instance, and remained so for some days previous to the explosion. The attendants became aware of its existence from the leakage that occurred, and, on the Sunday previous to the explosion, the foreman in charge of the boilers got inside the one in question, and assisted by the smith, patched it in the following way:—In the first instance they drove out four of the rivets, then laid over the crack a plate, which they daubed over with horse dung, in order to make good the joint and stop the leakage, fastening the plate down by four bolts passed through the holes in the shell from which they had previously knocked out the rivets. In this plastered state the boiler worked on from the Monday morning till the following Saturday, when the explosion took place.

"This does not appear to have been the first, but the third time that this system of patching had been adopted with this boiler, the identical plate used in this instance having been employed before for the same purpose, the foreman stating, that he had been shown how to do it by the boiler-makers when previously executing some repairs at the colliery.

"It is deeply to be regretted that the foreman did not at once lay off the boiler on detecting the crack. This would clearly have prevented the explosion, and he would have done so but for the inconvenience that would have followed the stoppage of the boiler, since there was not a spare one. A third was being laid down expressly for that purpose, but, as already stated, it was not yet quite ready for work. Under these circumstances, in an ill-judged moment, the patch was put on, with a view of tiding over the interval till the new boiler could start. Neither the foreman, nor the boiler-makers who advised him, could have been at all aware of the tendency of these boilers to rend at the transverse seams, or this patch had never been put on; and it is important to draw attention to this point, since it is feared that this dangerous mode of treating externally-fired boilers is not altogether singular.

"As the deaths resulting from this explosion occurred in different districts, two coroners' inquests were held. At one of these a very full investigation was made, evidence being given by a number of scientific witnesses, and the inquiry lasting over three days. Considerable unanimity existed among the witnesses as to the injurious character of the water with which the boiler had been fed, and a great many valuable facts were adduced, which had been met with by practical boiler-makers in the neighbourhood, attesting the liability of these externally-fired boilers to rend at the bottom of the shell through the transverse seams of rivets. One specimen, containing the overlap of the plates, was produced, which showed the rent running from rivet hole to rivet hole. This specimen had been cut out of a boiler only 3ft. 6in. in diameter, working at a pressure of 65lb. on the square inch, and the rent had occurred simply from a sudden rush of cold air being admitted on the opening of the furnace door in order to check the rising of the steam, immediately after the boiler had been briskly fired. Nothing surely need be added to prove, that boilers which are prone to rupture on the mere opening of the furnace door, cannot be of a safe class.

"The jury found a verdict of 'Accidental death,' and from the facts laid before them in evidence, stated—in addition to other conclusions they had arrived at—that they were unanimously of opinion, that the cause of the explosion was mainly attributable to the sedimentary character of the water, and also, that the Lancashire boiler was safer than the egg-ended boiler.

"To those who still continue the use of those externally-fired boilers the recommendations previously given can only be repeated, viz.:—

"1st. Heat the feed water before its introduction to the boiler, and disperse it by means of a perforated pipe carried horizontally for several feet near to the surface of the water, and thus prevent its impingement on any particular spot, especially near the firing end.

"2nd. Where the water is at all sedimentary an efficient blow-out apparatus should be attached and regularly used. Surface blowing-out by means of a scum pipe is particularly adapted to externally-fired boilers.

"3rd. Do not allow the flames to act too intensely on any one spot, but spread the action over as extended a surface as possible, and lower the fire bars should any signs of distress appear at the seams of rivets.

"4th. Have a spare boiler, so that defects may be suitably repaired immediately on detection, and the boilers regularly cleaned out without the necessity of Sunday work, a practice which is unadvisable though regarded only from an engineering point of view, is demoralising in its influence upon the workmen, and expensive to the steam user.

"5th. With regard to the construction of the boiler, secure good workmanship and material in the first instance. It is a mistake to consider that externally-fired boilers are better for being made of thick plates. Those under inspection which have given the least trouble have not been more than three-eighths of an inch in thickness, and it is thought that in plain cylindrical boilers this thickness should not be exceeded. In effecting repairs, as well as in the first construction, the rivet holes should be brought fairly one over the other, without straining, while drifting should not be allowed. In putting in new plates to old boilers, it will, in many cases, be advisable to cut away the old line of rivet holes and drill new ones; while the new work should rather be thinner than the old, instead of being thicker, as it sometimes is.

"These are, however, but ameliorative measures; while it is thought a more radical cure would be found in condemning these plain cylindrical externally-fired boilers altogether, and adopting those internally-fired in their place. It surely is no argument to object, that the Lancashire type of boiler, though successfully introduced into mills, is inapplicable to colliery purposes on account of the rough usage to which it would be exposed, since this is to make carelessness its own excuse, and to put a stop to all improvement.

"Although it can scarcely be necessary, yet it may perhaps be stated, in conclusion, that this Association must receive the co-operation of its members if it is to protect their boilers from explosion, and all its responsibility must clearly

cease, if between the times of its periodical inspection, the boilers are allowed, as in the present instance, to be patched and plastered without its knowledge.

"For the present month I have to report the occurrence of two explosions, by which one person has been killed and three others injured. These boilers, which were not under the charge of this Association, have neither of them been personally examined since their explosion. The following is the monthly tabular statement:—

From June 25th, 1864, to July 22nd, 1864, inclusive.

Progressive No. for 1864.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
18	June	Agricultural............................	1	3	4
19	July 3	2 boilers exploded simultaneously. Particulars not yet ascertained.	0	0	0
		Total..................	1	3	4

"No. 18 explosion occurred to a boiler employed for agricultural purposes, and at too great a distance from Manchester to admit of the scene of the catastrophe being personally visited, and but scanty reports have been received. It appears, however, that one person was killed and three others injured, while the boiler is stated to have been at work for twenty-three years, and frequently patched by country blacksmiths. It was rent into a number of small pieces, and scattered in every direction. This boiler was not under the inspection of this Association."

BOILER EXPLOSION AT THE VAUXHALL FOUNDRY, LIVERPOOL.

We give in our columns of "Notes and Novelties" of the present number, a short account of this explosion, to which we here refer on account of the circumstance, that, upon the face of what appears to have been the most searching examination on the part of competent and disinterested parties—no defect whatever seems to have been discovered whereby to trace the cause of the explosion, as will be seen from the digest of the proceedings at the adjourned inquest, which was held on the 24th ult., upon the two men who had been killed.

John Myers, foreman of the turning and fitting department at the Vauxhall Foundry, stated he was going to his work, and was within 100 yards of the foundry, when he heard the explosion. On entering the yard he found that the boiler close by the erecting shop had burst. It was a tubular boiler, had been in use about nine months, and was made on the premises. Witness had seen the boiler working on the previous evening about nine o'clock, and at that time he saw by the gauge that the proper quantity of water was in it. The water should cover the tubes. If the water had escaped previous to the explosion, it would have scalded the men round about it. It was the engine-driver's duty to see that the proper quantity of water was in the boiler, the engine-driver for the night shift being on duty from eight o'clock, p.m., till six o'clock the following morning, the engine-driver for the day shift doing duty from six o'clock in the morning till eight o'clock at night. There were only two engine-drivers. The boiler was supplied with water by a pump worked by the engine. There was no diffilty in ascertaining at any time whether there was a sufficient quantity of water in the boiling or not. The water gauge was placed on the front over the boiler door, where the engine driver could see it. Witness could give no opinion as to the cause of the explosion.

Thomas Woods, an engine driver in Messrs. Forrester's employ, said that on the evening of the 17th ult., at eight o'clock, he took charge of the boiler which exploded, and remained until the explosion took place, at seven minutes past six o'clock on the following morning. On giving up the charge to James Goulburn at six o'clock, witness looked at the water gauge and saw by it that there was sufficient water in the boiler. Goulburn also looked at it, and made no remark about it. Since he had been in the hospital Goulburn had said that there was sufficient water in the boiler. Witness was bidding him "good morning," and was on the point of leaving when the boiler exploded. Witness could form no opinion as to the cause of the explosion. The boiler seemed to be very tight, and he had never seen it leak a drop. Had never heard that anything was the matter with the boiler. Had been in charge of the boiler about four weeks.—By Mr. Banner: The safety-valves were in order when witness gave the boiler in charge to Goulburn, and the steam was blowing off.—By the Coroner: I was blown across the yard by a current of air or steam, and was drenched with water. Between two and three weeks before the explosion the boiler was cleaned, and it was to have been cleaned again on Sunday last. Had never seen the boiler examined.

Thomas Pargeter, foreman boilermaker at Vauxhall Works, said—I arrived at the Works about ten minutes after the explosion. The deceased had been removed before I got there. The boiler which exploded was under my supervision. It was a vertical tubular boiler. The inner shell of it was 7-16ths of an inch thick, the top ½in., and the outside shell 7-16ths. It was 15ft. 7in. high over all. The lower part of the shell was 4ft. 7in. in diameter. The steam part was 4ft. 5in. high and 7ft. in diameter. The vertical furnace 7ft. high and 3ft. 3in. diameter, with two internal flues 10in. diameter above the fire. From the top of the fire-box to the smoke-box were 117 tubes 1¾in. in diameter inside, stayed with four stays 1½in. in diameter. The materials composing the boiler in all its parts were of the best quality, and everything tending to safety was done in the construction of it. With ordinary care and attention the boiler should have lasted for nine or ten years. The boiler commenced working in February last as a new one, and had been working night and day ever since. All the boilers on the premises had a set time for cleaning—every three weeks or a month on the average—and I know that the rule was followed in the case of this boiler. Being a new boiler, I have not examined it every time it was cleaned; I examined the inside of the boiler some six weeks ago; the outer part I have seen every day since the boiler has been in use. I have never heard a complaint or noticed any defect about it—not even the smallest leakage. If there had been any defect I should have seen it myself. I can assign no reason for the boiler exploding.—By Mr. Banner: I have been with Messrs. Forrester and Co. for about eleven years. The making of boilers is one of their most extensive departments. In making this boiler the same care and attention were paid to it as making boilers for sale under order.. Speaking as a boilermaker, the boiler was amply and fully sufficient for its intended purposes. Supposing there there had been any defect in the manufacture it would have shown itself prior to this, having been working for nine months.

Mr. William Clay, manager of the Mersey Steel and Iron Works Company, deposed—I have carefully examined the boiler which exploded—in the first place with regard to the strength of the various parts; and in the next place, what was even more important, with regard to the workmanship. In my opinion the strength of the materials was quite sufficient, and the boiler was well made in every way. I could not detect a defective hole or rivet. I saw a piece of the plate tested at the Vauxhall Works, and the iron appeared to be of good and fibrous quality. I cannot form any idea as to the cause of the explosion, except that in some way unexplained there was a greater pressure than is indicated by the gauge. Messrs. Forrester have long had a great reputation as boiler makers, and in my opinion deservedly. The work on the exploded boiler leads me to say that they have maintained it up to the present time. I never saw a boiler with better workmanship upon it.—By a Juryman: I should have had no hesitation in working the boiler to a pressure of 100lbs. upon the square inch.

The Engineer, recalled, said that the maximum pressure allowed to be put upon the boiler was 70lbs.

Mr. James Kennedy, of Aigburth, formerly a partner in the firm of Messrs. Bury, Curtis, and Co., boiler makers, &c., said he had examined the exploded boiler, and found the materials to be very good, and the workmanship seemed also to be good. He generally agreed with the evidence given by Mr. Clay, and he thought the boiler might safely have been worked at the pressure directed. The safety valves were quite satisfactory; they were so large that they would allow five times the quantity of steam to escape that could be generated in the boiler. He could only account for the explosion by supposing that some increased pressure had been put upon the valves.

Mr. Lavington Evans Fletcher, chief engineer to the Association for the Prevention of Steam Boiler Explosions, said:—I have had great experience in the construction and working of boilers, and have examined a great number of exploded boilers. I examined this boiler a few hours after the accident. I examined it for several hours, and I found great difficulty in the solution of the cause of the accident. I formed the opinion that the boiler had been very faithfully and carefully made, and I should certainly have considered it safe to work it at a pressure of 70lbs. the square inch. I feel considerable difficulty in arriving precisely at the cause of the explosion. No doubt excessive pressure would have produced it, but I have not been able to learn that the safety-valve was deranged, or what was the cause of that excessive pressure.

Mr. Banner—If the accident had happened from defective workmanship, could the boiler have been worked for nine months without disclosing the defect?

Witness—I think it might; a bad plate might not have shown itself. But the plates have been tested since, and found correct. This explosion could be accounted for at once if it could be proved that by any accident anything was laid on the safety-valve, or that it became hampered. If one of the valves was blowing off, I do not think that sufficient steam could have been generated to cause the explosion. Sometimes the lock-up safety-valve will go out of play, and then there is only one valve to work.

I have known Messrs. Forrester and Co. for years, and they have a great reputation. In this case I should have myself passed the boiler as quite strong enough for the work.

The Coroner, in summing up, said it would be for the jury to say whether negligence was attributable to any one. It appeared that there was sufficient water in the boiler when the engineer on night duty was relieved, and the gauge was placed in such a position that it could be seen by everybody. After hearing the evidence of Mr. Clay, Mr. Kennedy, and Mr. Fletcher—the latter of whom was engineer for an association formed expressly for the purpose of preventing these accidents—he could not conceive that the slightest blame attached to Messrs. Forrester and Co., and in his opinion their reputation was not in the least degree affected by this inquiry. They had attempted to screen no one; and they had afforded every opportunity for a thorough inspection of the exploded boiler. Mr. Clay had stated that he would not hesitate to work the boiler at a pressure of 100lbs. per square inch, and it appeared that only a pressure of 70lbs. was put upon it. The materials and workmanship were stated by competent witnesses to be of the best quality, and under these circumstances he thought no other conclusion could be arrived at than that this occurrence was quite accidental.

One of the jury asked whether the evidence of Goulburn, the engineer, who took the place of Woods, had been taken.

Mr. Banner stated that inquiries had been made at the Northern Hospital that morning, and the medical men stated that Goulburn was in such a precarious state that it would be dangerous to put any questions to him.

After the jury had consulted for two or three minutes, the foreman said:—We are of opinion that the explosion was purely accidental, and that no blame attaches to Messrs. Forrester and Co.

The Coroner said he believed it was the intention of Messrs. Forrester and Co. to do something for the relief of the widows and children of the unfortunate men killed by the accident.

REVIEWS AND NOTICES OF NEW BOOKS.

Annuaire de la Société des Anciens Elèves des Ecoles Impériales d'Arts et Métiers. 16e Année. Paris: Eugène Lacroix.

The theoretical and practical knowledge of mechanical engineering is taught in France in three Government establishments, called Ecoles des Arts et Métiers—viz., the Engineering Schools of Châlons-sur-Marne, for the Northern and Eastern; Angers for the Western; and Aix for the Southern Departments. These schools yield to the country an annual supply of 300 engineers. The late pupils of the Ecoles des Arts form an association, with its seat at Paris, the object of which is "to establish a link of good-fellowship and to render beneficial to French industry the knowledge acquired at the schools," also "to issue an annual publication made up of papers written by the members of the society on engineering and other scientific subjects."

The last-issued annual—that of 1863—which we have before us is got up in a very elaborate and creditable manner. We notice among others a paper by Mr. Laurent on the hydraulic resources of Eastern Spain, illustrated by a geological map; there is also a well-illustrated account of the machine tools at the International Exhibition, by Mr. Chrétien. Mr. E. Jouvet, of Montivilliers, contributes an interesting paper on coupling gearing in screw cutting machines, with tables on the relation of the pitches to the diameters of screws; and Mr. Armengaud, ainé, treats us to an essay on the progress realized in industry, advocating his opinions on patent rights *pro aris et focis.* A report of the committee of the society is appended.

Practical Illustrations of Modern Land and Marine Engines. By N. P. Burgh. London: E. and F. N. Spon. 1864.

Mr. Burgh, who is favourably known to us as an engineering draughtsman, has published a collection of twenty plates of steam engines, boilers, paddle-wheels, and propellers, drawn to a scale unusually large for illustrative plates, and thereby of proportionately increased value to the engineer and student.

A page of letter-press affords a means of reference, not alone to the plates and figures, but also to the dimensions and relations of one part of the machinery or apparatus to another. Indeed, the plates are available as practical working drawings.

On the Application of Cast and Wrought Iron to Building Purposes. By William Fairbairn, C.E., F.R.S., F.G.S. Third Edition; to which is added a Short Treatise on Wrought Iron Bridges. London: Longman, Roberts, and Green. 1864.

To the various useful books which Mr. Fairbairn has from to time produced, is now added the very important and valuable matter introduced by him in the third edition of his treatise "On the Application of Cast and Wrought Iron to Building Purposes," and which, too, he has supplemented with a short treatise on wrought iron bridges, bringing the result of practice down to the present date.

This third edition is an admirable and most complete treatise, and should be in the hands of every engineer, contractor, and worker in or user of iron.

England's Navy Unarmed. A Series of Letters to the First Lord of the Admiralty, and Published in the *Daily News*, Presented to both Houses of Parliament. By Rear-Admiral Halstead. J. B. Nichols and Sons, 25, Parliament-street, Westminster. 1864.

An admirable pamphlet, which must be read to be thoroughly understood and appreciated.

BOOKS RECEIVED.

"Railway Accidents; their Causes and Means of Prevention." By Mr. Jas. Brunlees, M. Inst. C.E.

"Excerpt and Minutes of Proceedings of the Institution of Civil Engineers. 1861-62.

"Introductory Report of the United States Commissioner of Patents for 1863."

NOTICES TO CORRESPONDENTS.

H. S. (Copenhagen).—Your suggestions are correct, and in conformity with Rule XIV. The error arises from the author having taken only the half displacement for his calculations of the centre of gravity, on the preceding page, which was quite correct; but, for the calculations respecting the meta-centre the entire displacement must be taken; you may convince yourself of this, also, by the demonstration given on page 114 of Mr. Peake's work. We deem it our duty, with respect to the treatise you have been quoting, to append the following opinion of a practical ship-builder:—"I should pity most heartily the naval architect who would be compelled to learn the theory of his profession from this work. It is the most indigestible compilation of formulæ I ever saw in a book which professes to be practical. I defy anybody to make the simplest calculation of displacement under the guidance of this book, unless he invents himself those methods which everybody uses, and which cannot be found anywhere in the work alluded to."

A Subscriber (Brest).—Send us your address, and we will request Messrs. E. and F. N. Spon to forward you a list of books upon the subject in question, together with their prices.

J. W. (India).—Your communication is being prepared for publication.

B.—Yes; it would be the subject for a patent. Send the particulars to the Director of the Artizan Patent-office, at the office of this journal, and you will receive full information.

D. K. and others will be replied to in our next.

S.—We will communicate with you through the Post.

RECENT LEGAL DECISIONS
AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

Under this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

Roberts *v.* Rose.—In this case the plaintiffs had obtained leave from the occupier and agent of the owner of certain land to make a watercourse over it. The owner subsequently leased the land to the defendant, who, as well as the agent of the owner, gave the plaintiffs notice to discontinue the watercourse. On their refusal the defendant stopped it at the place where it left the plaintiff's premises, and it came upon the land of the occupier, and so caused damage. It was held by the Court of Exchequer—firstly, that the lease was a revocation of the licence; secondly, that the defendant was right in stopping it where he did, as the plaintiffs had failed to show that it could have been stopped elsewhere with less damage to themselves, to the defendant and the occupier, or any third person.

Colliery Case.—Recently, at the Caerphilly (Glamorganshire) petty sessions, Mr. Crawshay Bailey, M.P., and Mr. Edmund D. Williams, proprietors of the Carugethin Colliery, were summoned for not providing a proper screw, or other suitable implement, for keeping the two wheels of the winding machinery in permanent gear, as required by the special rules under the 23rd and 24th of Victoria, cap. 151. Mr. Badgate appeared in support of the information, instructed by Mr. Lionel Brough, the Government inspector of mines for the district, and Mr. Carter, from Messrs. Woodhouse and Colborne, represented the defendants. The case had been adjourned from a previous sitting in consequence of an objection made on behalf of the defendants that the acting manager, if any, was liable, and not the proprietors. Mr. Lionel Brough was examined, and he proved that before the accident at the colliery there was not a proper screw to keep the winding machinery in permanent gear. The magistrates decided that the case was proved against Mr. Edmund D. Williams, he being the acting partner, and the mitigated penalty of £10 and costs was inflicted.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

Enormous Casting.—The casting of a 160-ton anvil block was recently successfully accomplished at Messrs. T. M. Stanley and Co.'s, of the Midland Works. The casting shop in which the monster was brought into shape and form was that in which the previous castings had been made. In the centre of the floor a great pit was dug, and in this the mould was framed, the anvil being cast with its face downwards. The mould was 12ft. square at the base, and 11ft. 6in. deep, and it was estimated that nearly 170 tons of iron would be required to fill it. At intervals outside the shop were five furnaces, and at six o'clock in the morning these commenced to pour their molten contents into a huge chasm, and continued until about five o'clock, when the operation was declared to be successfully completed. The scene in the casting-shop was most animate. From four or five different points streams of liquid fire were slowly rolling to the edge of the pit, where they fell, amidst showers of starry sparks, into the vast mass beneath. A metal rod was thrust through the mass to test its perfect liquidity, and this having been satisfactorily proved, the top of the pit was carefully closed, to be opened no more until the metal has cooled, which would probably be in about seven weeks. The anvil is intended to be placed in the gun manufactory of Messrs. Firth, which is close to the Midland Works, on the Sheffield side of the second railway bridge. The predecessors of this anvil are fixed in an immense and admirably arranged forge, where seven huge Nasmyth hammers are continually employed in the forging of guns, and the great shafts and cranks of marine engines. The "160-ton" will be placed in a forge that is now building at the corner of the works nearest the railway. The block will have to sustain the blows of a 25-ton steam-hammer (Nasmyth), which will be employed in forging the 600-pounder and 300-pounder guns that Messrs. Firth are making for Mr. Whitworth.

Fire Insurance.—The annual return has been issued of all sums paid for duty on insurance against fire during the past year by each of the fire insurance companies of the United Kingdom. From this it appears that the amount paid by London offices was £999,971, and the country offices £715,152, the total being £55,207 in excess of the previous year.

Manufacture of Plumbago Crucibles.—To purify the plumbago used in the manufacture of crucibles, Mr. T. Vaughan Morgan proposes to bring the impure plumbago to a low red heat, in a close oven or retort. The iron is thus converted into a magnetic protocarbide, which is afterwards withdrawn by magnetic or electro-magnetic action.

Finance Accounts of India.—The official finance accounts show that the gross revenue of India for the year ending the 30th of April, 1864, is estimated to have been £44,753,500, but charges of collection, and cost of salt and opium, and allowances under treaties and otherwise, and repayments, reduce this sum to a net income of £35,946,700. Of this amount the land revenue and tributes produced £18,488,050, or more than half; salt, £4,929,250; opium, £4,740,550; customs, £2,041,420; stamps, £1,598,280; assessed taxes, £1,325,950. The expenditure is estimated at £35,688,811, leaving a surplus of £257,889. The expenditure for the army is estimated at £12,765,281 in India, and £1,849,304 in England. The interest on the debt is £5,247,569. The payments for guaranteed interest on the capital of railway and other companies are stated at £2,489,075, from which must be deducted £916,667 for net traffic receipts, reducing this item to £1,572,408.

The London Coal Trade.—For the month of August the quantity of coal conveyed to the metropolis by the railway was 186,499 11cwts., against 126,274 tons for the corresponding month of last year; and the seaborne 250,886 tons against 259,817 tons for August, 1863. Of the railway tonnage, 70,402 tons 17cwt. was carried by the London and North-Western Company 62,279 tons by the Great Northern, 20,370 tons by the Great Western, 17,807 tons by the Great Eastern, 11,177 tons 10 cwt. by the Midland, 632 tons 2 cwt. by the London, Chatham, and Dover, and 36 tons by the Tilbury and Southend. The total railway supply for the present year has been 1,316,192 tons 10 cwt. against 927,545 tons 7 cwt. for the first seven months of 1863, or an increase of 388,647 tons 3 cwt. The supply by water has been as follows:—Newcastle, 95,651 tons in 198 ships; Seaham, 15,058 tons in 63 ships; Sunderland, 71,859 tons in 158 ships; Middlesborough, 7,120 tons in 28 ships; Hartlepool, and West Hartlepool, 41,568 tons in 153 ships; Blyth, 286 tons in one ship; Scotland, 760 tons in six ships; Wales, 12,454 tons in 26 ships; Yorkshire, 2,047 tons in 25 ships; 2,838 tons of small coal in four ships, and 1,245 tons of cinders in ten ships. The comparative statement shows that this year, as compared with the first seven months of 1863 there has been a decline of 399 ships, and an increase of 18,004 tons, that for 1863 being 1,837,644 tons in 5,429 ships, against 1,855,648 tons in 5,030 ships for January to July 30th inclusive of the present year.

Bills Passed.—Since our last the Royal assent has been given by commission to the following bills:—Consolidated Fund (Appropriation), Exchequer Bonds (£1,600,000), Fortifications (Provision for Expenses), Scottish Episcopal Clergy Disabilities Removal, Turnpike Acts Continuance, Registration of Title Deeds (Ireland), Ionian States Acts of Parliament Repeal, Turnpike Trusts Arrangements, Bank-notes, &c., Signature; Defence Act Amendment, Accidents Compensation Act Amendment, Burial Registration, Bleaching and Dyeing Works Act Extension, Sale of Gas (Scotland), Justices' Proceedings Confirmation (Sussex), Expiring Laws Continuance, Bank Post-bills (Ireland), Corn Accounts and Returns, Westminster-bridge Traffic, Stamp Duties Act (1864) Amendment, Naval and Victualling Stores, Public Schools, Civil Bill Courts (Ireland), Harwich Harbour Act Amendment, Portsmouth Dockyard Requisition of Land, Local Government Supplemental (No. 2), Criminal Justice Act (1855) Extension; Armagh Archiepiscopal Revenues, New Zealand (Guarantee of Loan), Public Works (Manufacturing Districts), Poor Removal, Sheriffs' Substitute (Scotland), Drainage and Improvement of Lands (Ireland) Supplemental, West Indian Encumbered Estates Act Amendment, Poor Relief (Metropolis), Weights and Measures (Metric System), Limited Penalties, Cranbourne-street, Salmon Fisheries (Scotland) Act Amendment, Poisoned Flesh Prohibition, &c., Naval Discipline, Judgments, &c., Law Amendment; Highways Act Amendment, Railway Companies' Powers, Contagious Diseases, Thames Conservancy, Railways Construction Facilities, Improvement of Land Act (1864), Pier and Harbours Order Confirmation, Dublin, Rathmines, and Rathgar, &c., Railways; Great Eastern Railway Junctions, Alford and Mablethorpe Railway, Drayton Junction Railway, East Gloucestershire Railway, Glasgow City Union Railway, Kingsbridge Railway, Lancaster Canal Transfer, Launceston, Bodmin, and Wadebridge Junction Railway, Liverpool Central Station Railway, Metropolitan Railway (Notting-hill and Brompton Extension), Scottish Central Railway (Stations), Swansea Vale and Neath and Brecon Junction Railway, Tamar, Kitthill, and Callington Railway, Worcester, Dean Forest, and Monmouth Railway, Great Northern and Western (of Ireland) Railway (No. 2), Kilkenny Junction Railway, Parsonstown and Portumna-bridge Railway, Much Wenlock and Severn Junction and Wenlock Railway Companies, Metropolitan and St. John's-wood Railway, Alton, Alresford, and Winchester Railway, Brecon and Merthyr Tydvil Junction Railway (new lines), Dublin Improvement, Great Western Railway, North Devon and Somerset Railway, North Staffordshire Railway (New Works and Silverdale, Madeley, and Drayton), Petersfield and Bishop's Waltham Railway, South-Eastern Railway, Cannock Chase and Wolverhampton Railway, Great Eastern Railway (Metropolitan Station and Railways); London, Brighton, and South Coast Railway (Additional Powers), Metropolitan Railway (Trinity-square Extension), North Brecon Railway (Extension, &c.), Portpatrick Railway Portpatrick Railway (Steamboats), St. Helen's Canal Railway, South Wales Mineral Railway, Exmouth Dock, Manchester, Sheffield, and Lincolnshire Railway (Steamboats); Dublin Trunk Connecting Railway, Metropolitan District Railway, North-Western and Charing-cross Railway, Sheffield Waterworks (Bradfield Inundation); Tooting, Merton, and Wimbledon Extension Railway; Aldborough Pier and Railway, Bembridge Railway Tramway and Pier, Holywell Railway, and Dublin and Baltinglass Junction Railway.

New Method of Hanging Doors.—Mr. George Fawcus, of North Shields, with a view to obviate the accidents that are liable to happen in the opening or closing of doors fitted as at present, proposes to form a groove (a segment of a quarter circle) on the back of the door, making it to revolve round the shaft of a pillar tube, or circular moulding, fitted to the door frame. The ordinary butt or other hinges at the back of the door are to be replaced by pivot points, plates, and screws, hands or crooks, at the top and bottom of the door, the combination acting like a rule joint, and so presenting no opening at the back, in whatever position the door is placed. The doors may also be hung in the centre of the side frame, and so present the same appearance of door and frame on both sides. The door frames may be made of wedge-shaped sections to economise timber, as these may be cut obliquely from square pieces. More space will thus be gained in the doorway for anything of length passing through obliquely. There may be graceful curves, that is, rounds and hollows, instead of the mouldings with sharp corners, that so much increase the labours of the jobber, painter, &c. It is expected that doors thus fitted will be less liable to be affected by warping, and will move more easily. The ordinary bolts of spring locks may be made broader and rounded off with a bulb edge, through which a small level surface in the middle may be slotted out for holding, thus exposing no sharp corner or edge for contact in passing.

Petroleum Oils.—The following instructions, relating to the use of these oils for lighting purposes in Paris, have been approved by the Prefect of the Seine, and published:—As there is danger in the use of petroleum oils, it is important that the public should be made acquainted with the precautions by which this may be avoided. Petroleum, properly purified, is also colourless. The litre should weigh not less than 800 grammes. It should not at once take fire on being brought into contact with a lighted body. This essential condition may be easily tested. A small quantity of the oil should be poured into a saucer and the surface touched with a lighted match. If the petroleum has been deprived of the light and very inflammable oils, it will not only not take fire if a lighted match be thrown into it, but the match itself, after burning for an instant, will be extinguished. All mineral oils intended for lighting purposes, which will not stand this test, should be rejected as extremely dangerous. Petroleum oil, even when deprived of the very light spirit called naphtha, which renders it inflammable in contact with flame, is nevertheless one of the most inflammable materials known. If poured on linen cloth or woollen fabrics its inflammability is greatly increased, and great care is needed in its storing and sale. It should be kept or carried in metal vessels only, and the stores where it is placed should be lighted either by outside lamps or safety lamps. A lamp for burning petroleum and this class of oils must have no cracks or flaws in the parts surrounding the wick. The receptacle for the oil should be sufficiently large to hold more than enough oil for each burning, so that the lamp may not become empty whilst burning. Transparent receptacles, such as glass or porcelain, are to be preferred, as the quantity of oil contained may be seen. The receptacle should be thick, and the adjustments should be fixed on it, not merely by tight fitting, but by means of some cement not affected by the mineral oil. The stand of the lamp should be heavy and with a broad base, to ensure steadiness and render it less liable to be upset. Before lighting a lamp it should be completely filled, and then carefully closed. When the oil is nearly come to an end the lamp should be extinguished and allowed to cool before it is opened for refilling. In case, however, it is necessary to fill the lamp before it is quite cool, it is absolutely essential to keep carefully at a distance any light which may be wanted during the operation. If the glass of the lamp breaks, it should be extinguished at once, to prevent the heating of the fittings, for such a heating may be sufficiently intense to vaporise the oil in the receptacle; the vapour may take fire, ending in an explosion destroying the lamp, and scattering in all directions a liquid at all times inflammable and frequently in an inflamed state. The best materials for extinguishing these oils when burning are sand, earth, and ashes, which are very superior to water. In case of burns, and before the arrival of a medical man, it will be found useful to keep the wounded part covered with linen rags kept continually moistened with water.

The Metric System.—An Act of Parliament has just been printed to render permissive the metric system of weights and measures. It recites that for the promotion and extension of our internal as well as our foreign trade, and for the advancement of science, it is expedient to legalise the use of the metric system of weights and measures. It enacts that, notwithstanding everything contained in any Act of Parliament to the contrary, no contract or dealing shall be deemed to be invalid or open to objection on the ground that the weights or measures expressed or referred to in such contract or dealings are weights and measures of the metric system, or on the ground that decimal subdivisions of legal weights and measures, whether metric or otherwise, are used in such contract or dealings. In a schedule annexed to the act, the equivalent of metric weights and measures are set forth.

Improved Amalgamator.—Mr. Chas. Camp, of San Francisco, California, has invented an improved amalgamator, in which the crushed quartz is ground between annular disc mullers and spiders. These mullers are revolving (different from the other pans), with a horizontal shaft, on a vertical plain, on vertically placed spiders. By a peculiar arrangement the inventor applies four mullers and four spiders, attaining by this means four pairs of grinding discs, so that such a pan, of the same diameter as the ordinary pans, has four times as much grinding surface, and should, therefore, grind four times as much quartz pulp. The mullers and spiders are brought into contact, and there kept

by means of a constant pressure, which is a great advantage over most other pans, where this pressure is greatly variable, and therefore the grinding irregularly performed. The amalgamating operation takes place in the lowest part of the pan, where the pulp is pressed through the quicksilver by aid of the centrifugal force of the mullers, and the arrangement is so contrived that the entire pulp ground between the mullers and the spiders is forced to go through the quicksilver again to the mullers, for re-grinding, and so on until the process is completed. The pan has a half cylindrical trough form, and is made of cast-iron. The advantages claimed for this pan are that quartz pulp is more regularly ground and amalgamated, and the quicksilver is not injuriously affected by any moving machinery. The price of such an amalgamator will be 25 per cent. less than that of ordinary pans of the same capacity for work.

COINAGE IN SPAIN.—According to the law issued last July, the standard of the Spanish monetary system is the *Escudo*—10 reales vellon, and the legal weight of the various coins will appear from the following table:—

Designation.	Value in Escudos.	Weight in Grammes.	Weight in dwts.	Weight in grains.
GOLD COINS.				
Doblon de Isabel	10	8·387	5	9·431
Do. of four Escudos ...	4	3·554 (?)	2	6·279
Do. of two Escudos......	2	1·677	1	1·830
SILVER COINS.				
Duro	2	25·960	16	16·624
Escudo	1	12·980	8	8·312
Peseta	0·40	5·192	·3	8·125
Media Peseta	0·20	2·596	1	16·63
Real	0·10	1·298	—	20·31
BRONZE COINS.				
Medio Real	0·05	12·500	8	0·904
Cuartillo	0·025	6·250	4	0·452
Décima.........................	0·010	2·500	1	13·581
Media Décima...................	0·005	1·250	—	18·790

The composition of the bronze coins is made up as follows:—Copper 95 parts, tin 4 parts, zinc 1 part. The allowance of weight, for the gold coins is $\frac{217}{100000}$, for the Duro and Escudo $\frac{2821}{1000000}$, for the peseta and media peseta $\frac{4991}{1000000}$, and for the real $\frac{9982}{1000000}$.

STEAM CULTIVATION.—At the Newcastle meeting of the Royal Agricultural Society, Messrs. Savory, of Gloucester, exhibited one of their patent double drum windlass engines to work in conjunction with an anchor pulley on opposite headlands. The double engine system of Messrs. Savory was exhibited by Messrs. Garrett. A separate prize of £50 had been offered for the best windlass engine. The judges, in awarding the prizes, concluded that Messrs. Savory's engine being only the motive or hauling power, did not come within the requirements of the prize, and, therefore, awarded them merely honourable mention. We notice, however, that Messrs. Garrett have published protests against this decision, inasmuch as they consider that in the objection advanced by the judges consists really one of the chief advantages of Messrs. Savory's system over that of Fowler's and others, as by it any description of cultivating implement may be used.

SUBAQUEOUS NAVIGATION.—The Messrs. James Russell and Sons, are now engaged in the manufacture of an extensive and very novel order for the Russian Government, who seem to have resolved upon making that country a great maritime power. A fleet of war vessels to sail under the surface are now being constructed for Russia. To afford some idea of the magnitude of the Russian enterprise, it may be stated that the cost of the tubes alone for a single vessel of this submarine fleet, will be nearly £9,000. It will contain no less than thirty-eight lengths of wrought-iron tubes of 60ft. each, having a 13-inch bore, and a thickness of seven-eighths of an inch. The specifications demand that they shall be capable of bearing a pressure of 2,000lb. to the square inch, and Messrs. Russell test every tube up to 2,500lb. The submarine boat which these tubes are destined for, is of such dimensions that it is estimated that 200 tons of iron and steel will be used in its construction. The cost will, it is calculated, reach 175,000 silver roubles, or £27,000, and the expenditure of this amount has been authorised by the Emperor. Each vessel is to have engines worked by compressed air, and to have a very strong break with provision for attaching large cylinders, charged with powder, to the bottom of vessels, to be fired by electricity. The parties navigating the vessel will see what they are doing by means of "bulls' eyes," and they will be able to regulate the depth at which they swim, generally keeping quite close to the surface.

NOVEL STEAM-ENGINE.—An engine, of novel construction and of Lilliputian size, has been made at the Midland Works, Sheffield, which unites great power with an economy of steam, and occupies remarkably little space. It is constructed upon the rotative principle, and has neither beam nor crank, but communicates the motion direct to the shaft, which passes through the cylinder. The dimensions of the engine are—Diameter of cylinder 15in., depth 7in., surface exposed to the pressure of steam 14 square inches. The height 3ft., breadth 2ft. 6in., and the width 16in. The inside of the cylinder is shaped like a heart, and the steam, injected at the top, acts upon a rotating barrel with a moveable bar, which at every turn catches the steam, and turns the shaft. There is no waste of power; and the motion is regulated by a steam cock placed on the injecting pipes. The great peculiarity of this engine is the facility with which the motion can be reversed, and that, too, without stopping or even slackening the speed. This is done by a handle at the top, which, when moved, injects the steam at either side of the cylinder, according to the way in which it is to be turned. As to the power of this minute engine, it is sufficient to say that it was driving two large fans—one $4\frac{1}{2}$ and the other 4 horse-power—which are usually driven by a 12 horse-power engine.

NAVAL ENGINEERING.

THE "CLIO," 22, screw steam corvette, 1,472 tons, 400 horse-power, was recently taken to the measured mile off Maplin Sands for the final trial of her machinery previous to her departure to the Pacific. The engines, which were built by Messrs. Ravenhill and Salkeld, worked very satisfactorily during the trial. The following were the results:—At full-boiler power, a mean speed of 10·990 knots per hour; revolutions of engines, 57; pressure of steam, 23; vacuum, 23; at half-boiler power an average of 9·805 knots; revolutions of engines, 50. The vessel went round the circle in 4min. 37sec. at full power, and at half-power in 5min. 33sec, the diameter of each circle being 286 and 358 yards respectively; the revolutions of engines in turning the circle were 54 and 41. The draught of water during the trial was 17ft. 8in. forward; 20ft. 10in. aft. The vessel is fitted with Smith's propeller, with the leading corners cut off; diameter, 16ft.; pitch, 26ft.; length, 3ft.; immersion of upper edge, 2ft. 4in.

FEDERAL SEA-GOING IRON-CLADS.—The *New York Times* gives the following list of sea-going iron-clads which the Federal States have either afloat or on the stocks:—It is well known that the Government never intended the 38 turretted vessels, now nearly all on active service, for cruising. They were improvised for harbour defence, and no specification in any contract required that they should be able to do ocean service. Many of them were, indeed, simple iron and wooden hulls, fastened to a sort of raft, and their forte was to be fighting, not sailing. Other ships were ordered for other purposes, and they will soon be tested, when the country and the press will have an opportunity to judge of their merits. Meantime it cannot fail to be interesting to furnish a list of that portion of the iron-clad navy of the United States which is destined for sea service:—

Name.	Guns.	Tonnage.	Condition.
New Ironsides	18	3,486	In commission.
Dictator	2	3,033	Afloat.
Puritan...	4	2,265	Afloat.
Mantanomah	4	1,564	Afloat.
Monadnock	4	1,564	Afloat.
Tonowanda	4	1,564	Afloat.
Agamenticus	4	1,564	Afloat.
Dunderburg	10	5,090	Ready to launch.
Passaconomy	4	3,200	Building at Portsmouth.
Quinsegamond	4	3,200	Boston.
Kalamazoo	4	3,200	New York.
Thackmaxon	4	3,000	Building.

Two of the last-named fleet are now so forward that they may be completed this year. It will be observed that there is no vessel in the list of a less measurement than 1,500 tons, while eight of them are of greater tonnage than the screw line-of-battle ships in the French and English navies. As regards their ability to go to sea it is only certain that they were built for no other purpose than to cruise at sea, and to serve at home when no cruising is to be done. [Our New York contemporary does not seem to be aware that the English navy includes the following armour-plated ships:—*Achilles*, afloat, 6,121 tons; *Agincourt*, building, 6,621 tons; *Black Prince*, in commission, 6,109 tons; *Caledonia*, afloat, 4,125 tons; *Defence*, in commission, 3,720 tons; *Hector*, afloat, 4,089 tons; *Lord Warden*, building, 4,067 tons; *Lord Clyde*, building, 4,067 tons; *Minotaur*, afloat, 6,621 tons; *Northumberland*, building, 6,621 tons; *Ocean*, afloat, 4,047 tons; *Prince Consort*, in commission, 4,045 tons; *Royal Alfred*, building, 4,045 tons; *Royal Oak*, in commission, 4,056 tons; *Royal Sovereign*, in commission, 3,963 tons; *Valiant*, afloat, 4,063 tons; *Warrior*, in commission, 6,109 tons; *Zealous*, afloat, 3,716 tons. Ships of the *Resistance* class are not included in this list.]

THE TRIAL OF THE DOUBLE SCREW STEAM LAUNCH, fitted as a steam tender for H.M. iron screw frigate *Achilles*, 20, 1,250-horse power, took place at Chatham on the 11th ult. The screw launch is the second which has been constructed on the twin-screw principle for the *Achilles*, the first vessel of the kind on its completion having been transferred to the *Bombay*, 80, flag ship, on the south-east coast of America, on that vessel leaving Chatham. The extreme length of the little craft is 42ft., and breadth 11ft. The engines, boilers, &c., occupy a space amidships of about 8ft. by 4ft. 3in. They were constructed by Messrs. Maudslay, Sons, and Field, and are of high pressure. They are nominally of 3-horse power, but can be worked up to at least 20-horse power, should occasion require. Their total weight, including 9cwt. of water in the boilers, is 4 tons 7cwt. There are four cylinders, each with a diameter of 4in., and a length of stroke of 6in. The length of the screw shaft is 18ft. Each of the two screws is four-bladed, with a diameter of 2ft., and they are set at a pitch of 3ft. $4\frac{1}{2}$in. Both screws are driven by means of their own independent shafting, which thus enables each to be worked in contrary directions. The draught of water during the trial was 3ft. 6in. aft, and 2ft. 2in. forward. The steam launch left the dockyard at two o'clock, and at once steamed out into the harbour, when the advantages possessed by the double screw were soon apparent in the remarkable ease with which the steam launch was steered among the vessels and other craft beating up the harbour. With a pressure of 70lb. of steam, and the screws making from 300 to 330 revolutions per minute, a speed of between six and seven knots per hour was obtained. After running some distance down Gillingham Reach to Folly Point, and past the *Achilles*, the launch was tested in making circles with both screws in use, when with the propellers working in contrary directions, the full circles were turned in one-half the time occupied in turning with the screws revolving in the same direction. This part of the day's trials having terminated the launch steamed to the Dockyard Pier, and afterwards proceeded up the harbour to Rochester-bridge, where the steaming qualities displayed by the miniature vessel were equally satisfactory.

PROTECTING ARMOUR PLATING.—Great success has attended the plan adopted for protecting the armour-plating of the iron-cased wooden frigates, as applied in the first instance to the *Royal Oak*. This vessel has been] admitted into the dock at Malta for the purpose of ascertaining the results of the measures adopted for preventing the effects of galvanic action on the armour-plating. The plan, which was suggested by Mr. Reed, the chief constructor of the navy, consists in sheathing the plates with teak planking three inches in thickness, the inside of the planking and the surface of the armour plating being at the same time coated with Hay's waterproof glue, and the planking attached to the armour-plates by means of short screws. Since the *Royal Oak* has been in dock at Malta a portion of the planking has been removed, and the results have been in the highest degree satisfactory, the armour-plates having been perfectly protected, while not even the slightest trace of galvanic action can be detected. This improvement in the way of preserving the armour-plating of wooden frigates is the more important when it is recollected how seriously the plates of the *Royal Oak* were found to have suffered only a very short time after the frigate had been launched, on the vessel been docked and inspected in this country. Mr. Reed's plan has subsequently been applied to the *Ocean*, armour-cased frigate, at Devonport, and so satisfied are the Lords of the Admiralty with the results in the case of the *Royal Oak* that they have ordered the whole surface of the armour below the water to be protected in the same way, and the work will be carried out at Malta dockyard.

THE "ROYAL SOVEREIGN," turret ship, in dock at Portsmouth, is ordered to be fitted with a hand of wooden sheathing at her water line, and the work has been commenced by the dockyard authorities. Iron straps 3in. wide by $\frac{3}{4}$in. thickness and about 6ft. in length, and averaging about 30in. apart, will be fixed on the armour plating by iron screws tapped into the face of the armour plates. Over these iron straps will be laid 3-inch wooden sheathing, scored to receive the straps and fill in the space between them, which will be fixed to the straps by screw fastenings.

THE "TERRIBLE," 21, 800 horse-power, the largest paddle-wheel steamer in the British navy, fitting for the first division of the steam reserve in the Medway, will, according to an announcement received at Chatham, be commissioned for service in the Mediterranean as soon as completed. During the time she was in dock she was almost rebuilt, and her engines and machinery taken out and thoroughly repaired.

THE FOULING OF IRON SHIPS.—The *Recruit*, iron paddle-vessel, 590 tons, 160 horse-power, has been taken into No. 2 dock, Sheerness, for the purpose of ascertaining the results of experiments with the compositions to prevent fouling invented respectively by Mr. Crispin, Mr. Wilson, and Mr. Hay. In November, 1863, the port side of the bottom of the *Recruit* was covered with Hay's composition, the starboard aft with Crispin's composition, and the starboard forward with Wilson's composition. The vessel was then

taken into Sheerness harbour, where she has since been lying at anchor. The following results were disclosed on examination:—It was found that the port side, which was covered with Hay's anti-fouling composition, and the starboard aft, which was coated with Crispin's composition, are both very foul, a large number of mussels, &c., closely adhering to the iron work. The forward starboard, which was covered with Wilson's composition, is, so far as fouling is concerned, comparatively free, and in a far better state than the parts that have had the composition of the other two manufacturers applied to them, though it was evident that a slight corrosion of the bottom of the vessel had taken place.

The "Urgent" troopship went out of harbour on the 5th ult., for a trial of speed at the measured mile. Six runs were made at full power, realising a mean speed of $10\frac{3}{4}$ knots, and two runs at half boiler power, at a mean speed of $7\frac{3}{4}$ knots. The average of her circles, with helm starboard at full power, was made in 11min. 21sec. helm at port in 10min. and 2sec.; at half-boiler power, with helm starboard in 11min. 55sec., and helm at port in 11min. 14sec.

The Mersey Rams, the *El Tousson* and *El Monassir*, purchased by the Government from Messrs. Bravay, have been handed over to Messrs. Laird Brothers, of Birkenhead, the builders, who have contracted with the Admiralty to complete them for sea. The vessels will be renamed respectively the *Scorpion* and the *Wyvern*. They are each to be armed with four 300-pounders, throwing a broadside of 1,200lb. The turrets are on Captain Coles's cupola principle.

Ships of War Building for the Royal Navy.—There are at the present time thirty-six vessels under construction at the various royal and private dockyards for the British navy, many of which are in a very forward state for launching. They consist of four iron screw ships, two iron-cased screw ships, one screw iron corvette, one double-screw iron gunboat, one double-screw iron and wood gunboat, nine screw frigates, three screw ships, two screw corvettes, four screw sloops, one paddle dispatch vessel, five screw gun vessels, and six screw gunboats.

Raising a Wreck by Pontoons.—The schooner *Seaview*, laden with 145 tons of coals, which was recently sunk in 60ft. of water in Douglas Bay, has been raised and carried in harbour by the pontoons of the Patent Atmospheric Marine Salvage Company (Limited.) As the case appeared to excite considerable interest from the novelty of the operation, we subjoin an account:—The pontoons are 2 large cylinders 73ft. long by 8ft. in diameter, and are provided among other things with columns passing through their centre, throwing all the weight of the wreck on the strongest part. The chains having been passed under the vessel by the divers, are made to come up through the columns of the pontoon, where they are made secure by a sliding bar of great thickness, called a chain-stopper. The apparatus was then attached at low water, and the wreck carried ashore by the rise of the tide, and was found to sustain very little damage except to her keel. The superiority of this novel method of raising wreck was strikingly exhibited in the instance of the *Three Daisies*, an iron steamer sunk at Barrow, on the 7th June last, where, after the combined efforts of seven schooners, had completely failed, the pontoons raised her with ease; and what is certainly deserving of mention, the successful operation did not cost the owner more than one-half the sum he had previously paid for the unsuccessful attempt.

Naval Appointments.—The following appointments have taken place since our last:—C. A. Bydder, Chief Engineer to the *Meanee*; R. Cook, Chief Engineer to the *Asia*, for the *Furious*; J. Torkington, Second-class Assist.-Engineer, to the *Prince Consort*; J. Bettruson, Engineer, confirmed in the *Advice*; J. Doris, in the *Virago*, promoted to Acting First-class Assist.-Engineer; J. C. Thompson, First-class Assist.-Engineer, and T. F. P. Shelley, Second-class Assist.-Engineer to the *Urgent*; W. Pilcher, Chief Engineer to the *Asia*, for the *Malacca*; T. F. Stimmons, Chief Engineer to the *Indus*, for *Wivern*; J. H. H. Smale, Chief Engineer to the *Indus*, for the *Scorpion*; J. Lovering, Acting Chief Engineer to the *Asia*, as supernumerary; J. Mears, Engineer, qualified for special charge in the *Victoria and Albert*; R. W. Jones, Engineer to the *Warrior*, W. Hair, in the *Hawke*, promoted to First-class Assist.-Engineer, J. B. Gibson, in the *Indus*, confirmed as First-class Assist.-Engineer, and G. Hosley, Assist.-Engineer to the *Asia*, for hospital treatment; A. Borthwick and W. C. Hilder, of the *Asia*, and J. M'Intyre of the *Royal Sovereign*, promoted to be Engineers; J. Barber, of the *Asia*, and C. J. Jerdan of the *Galatea*, promoted to be First-class Assist.-Engineers; F. Pugh, of the *Medusa*, T. Catchpole, of the *Asia*, and G. F. Sutton and J. Finlay, of the *Cumberland*, confirmed as first-class Assist.-Engineers; R. Irwin, of the *Wolverene*, and W. Savage, of the *Cumberland*, confirmed as Second-class Assist.-Engineers; and F. Smiley, Assist.-Engineer to the *Marlborough*, as Supernumerary.

MILITARY ENGINEERING.

The Lord Warden Target, which recently underwent such a severe battering during the late trials of ordnance at Shoeburyness, the particulars of which appeared in The Artizan, was landed at the Anchor-wharf, Chatham Dockyard, on the 16th ult. Since dockyard, and the two $4\frac{1}{2}$-in. iron. plates, as well as the $1\frac{1}{2}$ inner plates, and the trials the target has been taken to pieces by a party of mechanics sent from the dockyard, and the two $4\frac{1}{2}$in. iron plates as well as an inch and a half inner plates and the teak backing have all been returned to the yard. A careful examination of the armour-plates has been made by the officials of the department, in order to ascertain the quality of the iron of which they are formed, upwards of 1,000 tons of exactly the same kind of plates having been received at the dockyard to be bolted to the sides of the *Lord Warden* and the *Bellerophon* iron-clad frigates, now in progress. Twenty shots appear to have struck the two plates, one of them receiving 11 of that number. Of these, eight appear to have passed completely through the target, the remaining three causing only indentations. It is, however, with the quality of the iron that the officials are more particularly concerned, and in both plates, which were taken promiscuously from a stack of several hundreds of the same description, sent in from the Millwall Iron Company's Works, the iron was found to be as nearly as possible perfect in quality, which proves in a marked degree the rapid advance made by our principal iron companies during the last few years in producing serviceable plates. Notwithstanding the concussion to which this plate must have been subjected not a crack beyond a couple of inches, and that close to the apertures made by the shot, can be detected throughout its surface, while the closeness of the grain, as shown in the openings through which the projectiles made their way, proves the iron to be of an unusually excellent quality. The plates were of rolled iron, and for some distance along the edges of each the thickness of the various folds of metal can be easily determined by openings of greater or less extent.

Captain Palliser's improved system of strengthening the obsolete cast-iron guns, and rendering them available for the public service by the insertion of a wrought-iron tube, was on the 17th ult., tested at Woolwich with much success. One of the old 68-pounders, weighing formerly 95cwt. 1qr., cast at Lowmoor in 1859, and after considerable service condemned and branded with the broad arrow in testimony of its unfitness for further use, was fired twice at the proof butt in Woolwich Arsenal, with a charge of 16lb. of powder and shot weighing 110lb. each. The gun has been bored up to 13in., and and strengthened with a coiled tube reducing the bore to 7in. The present weight of the gun is 104cwt. The tube made in the Royal gun factories is of charcoal iron, and appeared to be perfect. After firing two rounds the screw nut at the muzzle was turned round, and the tube thereby turned out a short distance to see that it was not jammed in the gun, by which all the parts were ascertained to be correct. The gun was afterwards sent up to the Royal Gun Factories in order that the tube might be taken out, the breech-plug unscrewed from the tube, and the vent-bush inserted, and which, according to a suggestion of Capt. Palliser, will be screwed in from the interior of the gun. To prove the amount of resistance which it is expected the improvement will give to the old ordnance, the gun is ordered to be fired 1,000 times consecutively. The rifling is to consist of three grooves, and spiral for part of the bore. The spiral will be uniform, the final pitch of the rifling being a turn in $16\frac{2}{3}$ft. After completing the 1,000 rounds the gun will be despatched to Portsmouth for experiments on board the gunnery-ship *Excellent*, to test its power of penetrating the armour-plates.

Capt. Blakely's 11-inch cast-iron gun, hooped with steel, and which broke one of the hoops under proof a short time ago, having been repaired, has again been proved at the Woolwich butt. The gun is 15ft. long, 43in. in diameter at the breech, and 20in. at the muzzle. The gun was fired two rounds, with a charge of $52\frac{1}{2}$lb. of powder, and a cylinder weighing 540lb., and showed no signs of strain or damage. The gun, it is stated, is manufactured to the order of the Russian Government, and will now be despatched to St. Petersburg.

STEAM SHIPPING.

The Connecting Ship.—A prospectus has been issued of a company to be called the Connecting Shipowners, with a capital of £1,000,000, in shares of £20, for the construction of steamships on the connecting principle patented by Mr. Thomas M'Sweeney.

The "Mula," an iron screw steamer, recently launched by Messrs. Pile and Hay, for the Bombay and Bengal Steam Shipping Company, had her trial trip recently from Sunderland to the Coquet Island. The *Mula* is 550 tons register, 690 tons gross. The engines are by Mr. George Clark; they are of 100-horse power (nominal.) A number of gentlemen, friends of the builders, and others, accompanied the *Mula* to the Coquet, and the trip was in every way successful; the highest speed attained was 11 knots an hour, with a pressure of 22lbs.

The Trial Trip of the French Transatlantic Company's Steamer "Lafayette," has taken place at Cherbourg, under the auspices of a commission appointed by the French Government. The speed attained was very satisfactory, being slightly greater than that attained by the *Washington* (s.), belonging to the same company. The latter vessel made $13\frac{1}{2}$ knots per hour between the jetty and the English coast. The *Lafeyette* attained 13 and a little over two-thirds knots per hour over the same course.

Trial of the "Cawarra."—The official trial trip of the paddle-steamer *Cawarra*, recently launched from the building-yard of Messrs. A. and J. Inglis, Point House, for the Australasian Steam Navigation Company of Sydney, recently came off on the Clyde. In running the lights, a speed of 13 knots an hour was attained, partly against the tide, at a mean draught of 7ft., which was highly satisfactory to all concerned. Her dimensions are 210 by $25\frac{1}{2}$ by $12\frac{1}{2}$ft; tonnage, 650 tons n.m. The engines were made by the same firm, on the oscillating principle, of 160-horse power, fitted with patent feathering floats, and all other modern improvements in marine engines.

Iron Steamship Building at Southampton.—A large screw steamer of 2,500 tons, for the Hamburg and American Company, is now being built at the ironworks of Messrs. Day and Co., at Northam, with engines of 500 horse-power, fitted with surface condensers and other improvements tending to economise the consumption of fuel. There is also in course of construction at these works a screw steamer of 266 tons and 75 horse-power for the West Indies, together with a set of marine engines of 500 horse-power for the Peninsular and Oriental Company, and a large amount of boilerwork for the vessels of that company. A pretty yacht of 28 tons burden, 54ft. long, 11ft. broad, and 10ft. 3in. deep, built of iron and steel (the latter for lightness above water), and named the *Torpid*, has been launched from Messrs. Day's works. This yacht is the property of Mr. T. Seddon, of Liverpool, the owner of the well-known racing cutters *Astarte* and *Phryne*, and has been built for the special purpose of sailing against a cutter yacht named the *Thought*, built by Hatcher, of Southampton, the conditions of the race, which is to come off at Cowes, being that the winner is to become the owner of both yachts. The fine paddle-wheel steamer *Adriatic*, of 4,000 tons burden and 1,200 horse-power, the largest and fastest of the fleet of the "Galway line," is now undergoing a thorough overhaul of her machinery and hull in the Southampton Docks. On her last voyage from America to Liverpool *via* Galway an accident occurred in the machinery of this vessel which completely destroyed one of her steam cylinders, and as there are no cranes nor sheers on the Mersey which possess sufficient hoist for lifting such large masses from so deep a vessel as the *Adriatic*, she was taken round to Southampton—the sheers in the docks being the largest in the world—and placed in the hands of Messrs. Day and Co. for repair. The new cylinder lately cast for her by this firm to replace the broken one is the largest oscillating cylinder ever made in this country, its diameter being $100\frac{1}{4}$in., with a 12ft. stroke of piston; and, although the weight of this casting is no less than 35 tons, and the quantity of iron necessarily melted in the furnaces was above 42 tons, it appears to be as perfect in every respect as the smallest cylinder casting.

Steam Shipbuilding on the Clyde.—Messrs. Caird and Co., of Greenock, have contracted with the Bremen and New York Steam Packet Company for the construction of a large screw of the same dimensions and power as the *America*, built some time since by the same owners. Messrs. M'Nab and Co., of Albert-quay, have launched a screw, named the *Julia*, for Messrs. Seligman and Co., Glasgow. Her dimensions are:—Length, 155ft.; beam, 21ft.; and depth, 13ft. The *Julia*, which is now being fitted by Messrs. M'Nab with a pair of direct-acting engines of 60 horse-power, is the fourth steamer which the firm has launched for Messrs. Seligman since opening their yard. Messrs. Henderson, Coulborn, and Co., of Renfrew, have launched a paddle, built for blockade-running. The dimensions of this steamer are:—Length, 230ft.; breadth, 25ft.; depth, 11ft. 6in. The steamer, which received the name of the *Tartar*, is fitted with a pair of the builders' diagonal oscillating engines of 250 horse-power, nominal. Messrs. W. Simons and Co., of the Loreston Works, Renfrew, have launched a paddle of 700 tons, named the *Stormy Petrel*, built for a Liverpool firm, and intended for blockade-running. The dimensions of the *Stormy Petrel* are:—Length, 225ft.; breadth, 25ft.; depth, 11ft. 6in. She is fitted with oscillating engines of 160 horse-power, nominal. Messrs. Simons have two mail steamers of 1,000 tons each in an advanced state. Messrs. T. Wingate and Co., of Whiteinch, Partick, have launched a paddle named the *Armstrong*, 230ft. long, 26ft. beam, and 10ft. 6in. deep. The *Armstrong* is fitted with engines of 200 horse-power, nominal. The *Luzon*, built for Messrs. Ker, Bolton, and Co., by Messrs. A. Stephen and Co., of Kelvinhaugh, has made a trial trip, in which she attained an average speed of 11 knots per hour. The *Luzon* is intended to trade between Manilla and China. Messrs. Scott and Co., of Cartsdyke, have launched a paddle named the *Hattie*, originally intended for the passenger trade from Wemyss Bay, upon the opening of the new railway, but subsequently sold for the blockade trade. The *Hattie* is expected to steam at the rate of 20 miles per hour. Messrs. Aitken and Mansel, of Whiteinch, have launched a large paddle named the *Vulture*, 800 tons burden, and to be fitted with oscillating engines of 200 horse-power, by Messrs. James Aitken and Co., Cranston-hill. Messrs. Barclay, Curle, and Co. have launched from their Stobcross yard a screw named the *Argyll*, 220ft. in length, by 28ft. beam, and $15\frac{1}{2}$ft. depth. Her burden is 850 tous, and she will be fitted by her builders with geared engines of 125 horse-power. She has been built for Messrs. Cowan and Co., of Edinburgh, and others. The same builders have also launched from their Whiteinch yard another fine screw, named the *Dantzig*, 222ft. long, 29ft. beam, and 15ft. deep. The burden of this steamer is about 900 tons, and she is

being fitted by the builders with geared engines of 115 horse-power. She belongs to the Leith, Hull, and Hamburg Steampacket Company, and is intended for their Leith and Baltic trade. The London and Glasgow Engineering and Iron Shipbuilding Company has launched at Govan, an iron screw of 2,000 tons burden, named the *Propontis*, built for Messrs. W. H. and C. E. Dixon, of Liverpool. The dimensions of the *Propontis* are—Length of keel and forerake, 312ft.; breadth, 36ft.; and depth of hold, 25ft. This vessel, the first launched by the company, will be propelled by a pair of geared engines of 300 horse-power nominal.

IRON SHIPBUILDING ON THE TYNE.—A large iron steamship, of over 3,000 tons, to be named the *Ontario*, will soon be launched from Messrs. Palmer Brothers', building yard at Jarrow, on the Tyne, for the National Steam Navigation Company. She will be employed in the New York passenger and goods trade. Another vessel of the same size is building by Messrs. Palmer at Jarrow, for the National Steam Navigation Company. Messrs. Palmer have other vessels on hand in their large yard on the opposite side of the water at Howden, and they are fitting out a large screw collier, the *Orwell*, for the Lambton Coal Company, and a large screw the *Mermaid*, for the General Steam Navigation Company. Messrs. Marshall Brothers have on hand vessels for the Mediterranean and Calcutta trade, and are fitting out several tug steamers for the Thames and Liverpool. Messrs. Leslie, of Hebburn, are about to launch an iron screw steamer of 700 tons for the Leith trade. They are fitting out a steamer of 500 tons for India, and an iron screw steamer for Liverpool, and have on hand two large vessels for the Mediterranean trade. Messrs. C. Mitchell and Co., of Low Walker, have launched a paddle steamer for the New Zealand Government. This firm has also in hand a paddle steamer for Australia, a screw collier of 1,000 tons for the coal trade between the Tyne and France, a screw of 1,100 tons for the Chili trade, and three tugs for the Egyptian Government. Messrs. Wigham, Richardson, and Co., of the same place, are building a screw steamer, to be employed in the London and Limerick goods and passenger trade; two large steamers of 1,200 tons each; a paddle steamer and two large barges for India. Messrs. T. and W. Smith, of North Shields, are building two large screw colliers.

THE NEW SCREW STEAMER "DAMIETTA," built by Messrs. Backhouse and Dixon, went out of Hartlepool recently on a trial trip. The speed attained averaged 12½ knots, and the greatest satisfaction was expressed both with the result and the whole of the arrangement and workmanship of the vessel and machinery. The *Damietta* is 200ft. long, 27ft. broad, and 16ft. deep, and 635 tons, old measurement. The engines, manufactured by Messrs. T. Richardson and Sons, of Hartlepool, are of 80 nominal horse-power.

RACE BETWEEN TWO STEAMERS.—On the 20th ult., by special arrangement, a trial of speed took place from Holyhead to Kingstown, between the mail steamer *Ulster* and the *Banshee*, a vessel built by Messrs. Aitken and Mansell, of Glasgow, for the purpose of running the blockade. The *Ulster* left the harbour of Holyhead two boats' lengths ahead of the *Banshee*, which followed her out at 2.30 p.m. In ten minutes after this the *Banshee* came alongside her opponent, and, notwithstanding some loss of time occasioned by heated bearings, she reached Kingston 15min. before her, making the passage from the harbour wall to Kingstown in 3hrs. 25min., or at an average speed of over 18 statute miles per hour, and carrying 280 tons of dead weight. The *Banshee* is built of steel; she is 1,190 tons B.M., and is propelled by paddles driven by engines of 250 horse-power.

THAMES CONSERVANCY STEAM YACHT.—The small steam yacht used by the Conservancy Commissioners of the Thames for surveying the river above Kew is now being completely remodelled, with a view to increase her speed and improve her accommodation. Her old boiler and gear, weighing six tons, have been taken out, and replaced with the patent boiler of Mr. Roberts, of the Millwall Anchor Works, the latter weighing but two tons, and being provided with tubes round the fire-box, instead of the old plan of water spaces. The vessel, on the 23rd ult., proceeded from Millwall Pier to Kew on a trial trip, in charge of Mr. Leach, engineer to the Thames Conservancy. She performed the trip at the rate of thirteen miles per hour, with a less than ordinary consumption of fuel, and a pressure of 80lb. to the inch; her engines performed from eighty to ninety revolutions per minute.

LAUNCHES.

THE LAUNCH OF THE "BEBSIDE," screw steamer, from the yard of Messrs. J. Wigham, Richardson, and Co., of Low Walker, took place on the 18th ult. She is intended to develop the coal trade with France. Her dimensions are:—Length, 185ft.; breadth, 28ft.; and depth, 17ft.; with engines of 80 horse-power, by Messrs. R. and W. Hawthorn, of Newcastle. She will carry 900 tons of cargo and fuel. She was christened after the colliery whose coal she will carry.

TELEGRAPHIC ENGINEERING.

UNITED KINGDOM ELECTRIC TELEGRAPH.—The annual meeting of this company has been held. The report stated that since the last meeting the works completed and now in operation were as follows:—The section from London to Leeds, and across to Hull and Manchester, and Wakefield to Manchester, and the section from Wolverhampton to Manchester were opened between the months of October and March last. The section from Leeds to Newcastle-on-Tyne was opened in February, May, and July. The section from Newcastle-on-Tyne to Edinburgh and Glasgow was opened in May last, and the section from Oxford to Bristol and Cardiff in June last. This time last year 370 miles of line were in operation, and now there were 1,305 miles of line. The capital of the company on construction account amounted to £213,133, the remaining lines and extra works would be completed for £25,000, and the company's capital would thus be £238,133. For this the company would possess 1,658 miles of line and the working plant.

ELECTRIC AND INTERNATIONAL TELEGRAPH.—The report of the directors states that the prosperous condition of the country has caused great activity in every branch of the company's operations during the half-year. The gross income of the company for the half-year ending the 30th of June amounts to £136,473, showing an increase of £19,263 over that of the corresponding period of 1863. The expenditure, including the interest on the debenture debt and the sum voted to the late secretary, amounts to £87,643, or £9,495 more than in June, 1863. The net income of the half-year, after making every provision, amounts to £48,830. The directors recommend a dividend of £4 per cent. for the half-year on the stock and on the new shares, which will absorb £38,995, and leave a balance of £9,835 for the trust fund, which will then amount to £39,023.

RAILWAYS.

INDIAN RAILWAYS.—The annual report on Indian railways, by Mr. Jutland Danvers, the Government Director, brings the history of these undertakings down to the 31st of May last. The increased length of line opened since the preceding report was 358½ miles, which is less than half of the distance opened in each of the two preceding years, when the respective totals were 760 and 747 miles. Of the 4,786 miles at present sanctioned by the Government, the total length opened is 2,688 miles; and of the balance, 577 miles are expected to be completed in 1864, 159 miles in 1865, and the rest in 1866, and subsequent years. The whole capital raised by the various companies has been £54,285,088, and the expenditure £51,144,722. The total length of the line sanctioned last year shows an increase, owing to a decision that the line from Madras to Bombay should go from Gooty to Sholapore, *viâ* Baichore, and connect with Hyderabad and Ballery by a branch; also by an addition of 82½ miles to the Great Sothern line, to enable a junction to be formed between it and the Madras Railway at Errode, and also by an increase in the length of the Punjab and Delhi line. A further addition to the authorised total is at the same time contemplated by continuing the Raneegunge and Barrakur branch of the East Indian Railway to Lone Point on the main line near the Ganges. As the remaining works thus to be carried on are nearly as extensive, although not so costly as those already completed, English capitalists must calculate on a steady continuance of the drain which has now been kept up, generally with increasing force, for fourteen years. Of the capital paid during the period £32,648,923 has been expended in India, and £18,396,541 in England; nearly the whole of the latter, except such as has been disbursed for dividends, being also practically an expenditure in India since the payment in this country for iron rails and other materials to be shipped away, is in a great degree the same in effect as if we shipped in specie. And this drain is not relieved by investments on the part of the natives, since the total body of 33,358 shareholders in the proportion of these is only about 1 in 100. The general traffic returns of the past year are considered favourable; but, "although the traffic will undoubtedly be large, it still remains to be seen whether it will be worked with a corresponding profit. With good management and economy, however, and a judiciously-framed tariff of rates and fares, there is no reason for taking a discouraging view of the future." The confidence thus expressed will be shared by most people who consider the extent to which, by recent events, the development of India has been stimulated and established; but the modified tone adopted is a strong proof that, but for the impulse that India has received from changes which no one could be entitled to calculate upon, the expenditure hitherto incurred would have proved far too lavish for the first requirements of the country.

IMPERIAL MEXICAN RAILWAY COMPANY.—A prospectus has been issued of this Company. The line is to be from Vera Cruz to Mexico, with a branch to Puebla, comprising an aggregate length of 300 miles, of which a section of 25 miles from Vera Cruz has been open for some time. The capital for the purchase of this portion, and the completion of the remainder, is to be £5,400,000, one-half in shares, and the other half in bonds or obligations. Of the share capital of £2,700,000, the government take £800,000 a sum intended for the endowment of hospitals, and, therefore, to be inalienable; while £700,000 is to be taken in part payment for the portion of the line already executed. The amount for which subscriptions are invited from the English public, is, therefore, £1,200,000; at the same time, the government gives a subvention of £1,200,000 in 5 per cent. bonds, which are to be receivable for custom duties in the proportion of one-fifth in bonds, and four-fifths in cash. Among the other privileges granted, the most important are that the concession is in perpetuity, and that the company are to be free to fix their own tariffs both for goods and passengers, without any limitation—the present cost of conveyance being about £20 per ton for goods, and £11 per passenger. A contract for the entire completion and stocking the first line, has been entered into with the joint stock undertaking, Smith, Knight, and Co., for a sum within the capital of £5,400,000, and 8 per cent. interest during the construction is to be paid out of the State subvention of £1,200,000. The cost of the 25 miles already completed is not stated, but it is mentioned that the returns upon this portion have been equivalent to a profit of 11 per cent., reckoning the cost, at average per mile, which is to be expended on the entire line

LOCOMOTIVE WITH EIGHT DRIVING WHEELS.—On the floor of the library of the Society of Arts, may be seen a model of a locomotive engine with eight driving wheels, for sharp curves and steep gradients. The model is to a scale of one-eighth the full size. The frame is rigid, and is provided with eight driving wheels of differing diameters, so that the machine will roll freely round double reversed curves of one chain and-a-half radius. By this arrangement the total weight of the engine is rendered available for the purpose of adhesion, while the load is distributed over so many wheels as not to damage the rails. At the same time, by the application of a brake, to be operated by steam power, the whole of the eight wheels are retarded and set free rapidly by the driver putting steam on or off. The same machine is capable of being extended to twelve drivers if required. With the increase of steam power in the locomotive, the increase of of adhesive wheels has become a very important consideration. This is recognised on the Great Northern Railway, where Mr. Sturrock applies steam cylinders to his tenders to obtain the adhesion of an increased number of wheels, and thus, it is said, is enabled to draw one-half more load. By the system now shown, the increased power of adhesion is rendered compatible with the sharpest curves. This is a class of engine structure long aimed at by our friends on the continent, who have to work in hilly regions.

RAILWAY RETURN.—It appears from a return just issued by the Board of Trade, that the total receipts on railways in England and Wales for the year 1863, amounted, on 8,568 miles of railway, to £26,212,822, including £12,262,416 for passenger traffic, and £13,950,406 for goods traffic. The total receipts on the Scotch railways, 2,013 miles in length, amounted to £3,424,921, including £1,316,833 for passengers and £2,108,088 for goods. The total receipts on the Irish railways amounted, on 1,741 miles, to £1,518,654, including £942,279 for passengers, and £576,375 for goods. The total aggregate traffic receipts on 12,322 miles of railway in the United Kingdom for the year 1863, amounted to £31,156,397, and for the year 1862, on 11,551 miles of railway, to £23,128,558, showing an increase of 771 miles, and of £2,027,839 in the receipts, of which £1,418,296 was for goods traffic, and £609,543 for passenger traffic. The total number of passengers conveyed on lines in the United Kingdom during the year 1863, was £204,635,075, against £180,420,071, in the year 1862, showing an increase of 24,206,004 passengers. The total number of first-class passengers conveyed was 26,086,008, against 23,105,351 in 1862, showing an increase of 2,980,657. The total number of second-class passengers conveyed was 57,476,669, against 51,869,239 in 1862, showing an increase of 5,607,430. The total number of third-class, including parliamentary passengers, was 121,072,398, against 105,451,481 in 1862, showing an increase of 15,621,917. The total receipts from first-class passengers amounted to £3,368,676, against £3,332,380 in 1862, showing an increase of £36,296. The total receipts from second-class passengers amounted to £4,201,105, against £4,018,221 in 1862, showing an increase of £182,884. The total receipts from third-class passengers and Parliamentarians, amounted to £4,993,073, against £4,639,250 in 1862, showing an increase of £293,823. Considering the great obstructions to the accommodation of third-class passengers by most of the railway companies, the large increase in the receipts is very much more than could have been expected. The total working expenses amounted to £15,027,234, or 48 per cent., in 1863, and to £14,268,409, or 49 per cent., in 1862, showing an increase of £758,825, leaving the net receipts £16,048,931 for 1863, against £14,820,691 in 1862, showing an increase of £1,228,240 in the amount available for interest and dividends on the capital expended. The total amount paid up on shares and loans to the end of 1863, was £404,215,802, the total amount authorised being £474,999,545.

MINERAL TRAFFIC ON RAILWAYS.—The gross receipts acquired by the railways of the United Kingdom from mineral traffic—that is, from the carriage of coal, coke, and minerals—amounted in 1861 to £5,194,193; in 1862, to £4,957,406; and in 1863, to £5,419,667. Of the amount earned under this head last year, £4,504,434 was yielded by England and Wales, £885,080 by Scotland, and £30,153 by Ireland. This last line explains the woes of Ireland—in an eminently industrial age she is not industrial. The total movement of coal, coke, and minerals in England and Wales amounted last year to 55,613,641 tons against 51,442,381 tons in 1862, and 51,617,741 tons in 1861; in Scotland, to 12,194,972 tons, against 11,717,461 tons in 1862, and 11,766,600 tons in 1861; and in Ireland to 234,541 tons, against 246,016 tons in 1862, and 220,084 tons in 1861. These totals are extremely interesting, showing as they do the

revival of England and Scotland last year from the stagnation which prevailed during, at any rate, part of 1862, while in Ireland—worse luck!—matters exhibited last year no progress, but rather the reverse.

Railway Working Expenses.—The total working expenses of the railways of England and Wales in 1863 amounted to £12,659,618, against £12,050,581 in 1862; of the railways of Scotland to £1,617,204, against £1,520,056 in 1862; and of the railways in Ireland to £750,412, against £697,772 in 1862. The aggregate of the United Kingdom was thus £15,027,234 in 1863, against £14,268,409 in 1862. The length of line in operation at the close of 1863 was 12,322 miles, and at the close of 1862 11,551 miles. The totals given do not include steamboat, canal, and harbour expenses; and the figures for 1863 are also exclusive of the working charges of the Oswestry and Newtown, Cowes and Newport, Brecon and Merthyr Tydfil Junction, Cork and Kinsale Junction, Dowlais and Hereford, Hay, and Brecon. The ratio of expenses to receipts appears to have been reduced last year to 48 per cent., against 49 per cent. in 1862. The working expenses of last year may be analysed as follows:—Maintenance of way and works, 18·95 per cent., against 18·99 per cent. in 1862; locomotive power, 27·62 per cent. against 27·79 per cent. in 1862; repairs and renewals of carriages and waggons, 9·33 per cent., against 8·71 per cent. in 1862; traffic charges (coaching and merchandise), 27·92 per cent., against 27·95 per cent. in 1862; rates and taxes, 4·20 per cent., against 4·18 per cent. in 1862; Government duty, 2·63 per cent., against 2·63 per cent. in 1862; compensation for personal injury, &c., 1·19 per cent., against 1·11 per cent. in 1862; compensation for damage and loss of goods, 0·46 per cent., against 0·48 per cent. in 1862; legal and Parliamentary expenses, 1·30 per cent., against 1·54 per cent. in 1862; and miscellaneous, 6·40 per cent., against 6·62 per cent. in 1862.

Report on new Railways in the Vicinity of Liverpool.—Eccles, Tyldesley, and Wigan Railway.—This branch has been examined by the Government inspector, and arrangements are being made for opening it for public traffic immediately. The Edge-hill and Bootle Railway.—Of the 620,000 cubic yards of excavation on this branch, 465,000 yards have been removed. Of the 1,374 yards of tunnel, 1,319 are complete; and the bridges and other works are in a forward state. The land for the goods station at the north docks, or terminus of this railway, has been purchased, and the works will be commenced immediately. At Edge-hill, the new engine shed to contain 60 locomotives has been commenced, as well as the excavation necessary for the enlargement and re-arrangement of the station. Aston, Runcorn, and Ditton Railway (Runcorn Gap.)—The foundations of the piers for the 50 arches over the Ditton Marsh are complete; 20 of the piers are built to the height of the springing of the arch, and the rest to several feet above the surface of the ground. The foundations of 18 piers out of 33 of the viaduct through the town of Runcorn are complete. At the bridge over the river Mersey, the masonry of the Cheshire abutment has been built to 6ft. above the level of high water mark. Of the 42 caissons for the cast iron coffer dam for the river pier on the Cheshire side, 34 are to the rock, and 8 others in process of sinking. This portion of the work is now progressing rapidly, and as far as it has advanced, has fully realised the anticipations formed of this plan of dam. At the river pier on the Lancashire side, the wrought iron piling for the staging is being proceeded with, and the dam for this pier will be commenced immediately the machinery can be released from the Cheshire pier. The 5 piers of the 60-foot arches in the river have been commenced, and the masonry of three brought up the rock to low-water mark. The other works on this branch are progressing satisfactorily. Lime-street Station (Liverpool.)—The property required for the enlargement of this station and the erection of an hotel is being purchased, and as soon as possession is obtained, the works will be commenced.

RAILWAY ACCIDENTS.

Railway Collision.—On the night of the 10th ult., at about nine o'clock, a passenger train was run into by a goods train at the Priestfields Station of the Great Western Railway near Wolverhampton, and between that town and Birmingham. This day being one of the race days in Wolverhampton, there was a great deal of traffic, and the regular 8.30 train out of Wolverhampton was detained a quarter of an hour. At its arrival at Priestfield Junction, about $1\frac{1}{2}$ miles from that town, there was a quarrel in one of the carriages, and the train was somewhat delayed, while the station-master and the guard tried to quell the disturbance. A goods train followed the passenger train. The signalman at the junction, after allowing the passenger train sufficient time to stop and start again, permitted the goods train to come on, supposing that the passenger train had started. The goods train obeyed the signal, which being at a junction was one of caution. It was within 30 yards of the passenger train when the driver saw what was before him. He instantly reversed his engine and put on his breaks, but the discovery was made too late to prevent a collision. The passenger train had just begun to move when the goods train ran into it, and this prevented the accident from being very serious. The shock was felt throughout the whole of the four carriages of which the train was composed, and several of the passengers were slightly injured.

Railway Accidents.—In the year 1861 79 passengers were killed and 789 injured by railway accidents in the United Kingdom; in the year 1862 on an increased number of lines 35 passengers were killed and 536 injured; and in the year 1863 on a still increasing length of lines 35 passengers were killed and 401 injured. The number of passengers in 1863 was 204,635,075, without including 64,391 season and periodical ticket-holders. Estimating even that these last travelled on an average only 100 times each, the number of passengers killed in 1863 was less than one in 6,000,000, and of passengers injured less than one in 500,000. Of every five passengers killed three lost their lives through their own misconduct or want of caution, so that the number of passengers killed from causes beyond their own control was less than one passenger in 15,000,000. Of the passengers killed last year 12 met their deaths by getting out of, or attempting to get into, trains when in motion, five by incautiously crossing or standing on the line at a station, one by leaning out of the carriage window on approaching a bridge (since widened), one by getting out on the wrong side of a carriage, one (in Ireland) by getting upon the roof of a carriage and walking along the train. Of the 13 passengers killed in 1863 from accidents to trains, three lost their lives through collisions between trains, and ten from the trains getting off the line, 7 of the 10 in the accident on the Hunstanton line caused by a heifer being on the rails. Of the whole number of accidents to passenger trains in the United Kingdom reported to the Board of Trade in 1863—52 in all, exactly one a week, and precisely the same number as were reported to the Board in 1862—32 were caused by collisions with other trains, 10 by the trains getting off the rails, 6 by their running off the proper line through the points being wrong, and only four from anything breaking or getting out of order.

Explosion of a Locomotive.—On the forenoon of the 16th ult. a locomotive engine exploded on the line of the North London Railway at the Camden-road station. The platform at the Camden-road station extends from the entrance to the station at Great College-street to the eastern side of Great Randolph-street, where the line is some 30ft. above the level of the roadway. The bridge which crosses Randolph-street is composed chiefly of wooden girders, resting upon iron pillars and stanchions. It is the practice of the drivers of the up-trains to stop their engines just before reaching the western side of the Randolph-street bridge. The train from Kew due at Camden-road at 9.30 becomes at that station an express train to Stepney and Fenchurch-street, and is then taken on by another engine so soon as the engine which has brought it up shunts off. The train had arrived at the Camden-road station and taken in its passengers, when the engine No. 4 was brought up from its siding and attached to the train. The train had been brought up to about the middle of the Randolph-street bridge, and at the moment the coupling iron was affixed the driver of the engine was alarmed by hearing a report proceed from the fire-box of the engine, which caused him to jump off. The fireman was about to follow his example, but before he could do so a still louder explosion was heard, and the ponderous engine, upwards of 20 tons weight, flew high into the air, taking a forward motion and throwing down the buttress on which the eastern side of the bridge rested, and dashed over into the street below, turning over and completely round in its descent, but singularly enough alighting on its wheels. So high did the engine mount into the air that the whole of the telegraph wires on the northern side of the line, some 12ft. or 14ft. above the rails, were cut, and fell into the street below. The fireman was found some 20 yards off, fatally injured.

Accident in a Railway Tunnel.—On the night of the 22nd ult., a serious accident occurred in the Waterloo tunnel, which extends from Edge-hill to Great Howard-street, Liverpool. About eight o'clock eleven plate-layers in the employ of the London and North-Western Railway, left the Edge-hill station to proceed to the Waterloo station-yard to prepare metal for laying on the line and effecting certain repairs. When they had approached what is termed "the bank," in that part of the tunnel near Byrom-street, the truck upon which they were seated came into collision with a waggon of goods that was standing there, and so great was the force of the concussion, that the men were knocked off the truck and precipitated in all directions upon the line. The less injured of the number gave an alarm, and they were soon taken out of the tunnel—which was quite dark when the accident occurred—and conveyed to the Northern Hospital.

At the Junction of the West Midland and Taff Vale Extension Railway, at Pontypool-road, a collision between an excursion train and a mineral train occurred on the 22nd ult. The following are the particulars:—An excursion train left Worcester at 7.25 for Crumlin viaduct, one of the great attractions of Monmouthshire. All went on well until the train was on its way home and had travelled about six miles. the train consisted of ten passenger carriages and three break vans, each having a guard to work the break. They approached the Pontypool-road station at half-past five o'clock in the evening, and had been preceded about ten minutes by a coal train. Pontypool-road station is approached from Crumlin on a rather steep incline, descending to the station, and the run in is also on a sharp curve. The driver of the excursion train was coming down the incline, the signal being "all right" for his approach, when he saw the goods train on the rails in front of him. He immediately shut off the steam and whistled for the breaks to be put on, but the impetus with which the train was travelling rendered a collision unavoidable. The driver seeing this jumped off, and escaped unhurt, but the stoker, who stuck to the engine, was badly injured. Many of the passengers were severely injured.

Accident on the Manchester, South Junction, and Altrincham Railway.—On the morning of the 6th ult., an accident occurred near the Old Trafford Railway Station, on the Manchester, South Junction, and Altrincham Railway. It appears that the 8·40 train to Liverpool left London-road at its usual time, and on reaching Old Trafford, the engine, by some means, got off the line. This, of course, brought the train to a stand. The railway officials at once hoisted the danger signal, when, following immediately in the wake of the passenger train (which consisted of about five carriages), a luggage train came up also on its way to Liverpool; the latter consisted of about 24 or 25 trucks, some of them heavily laden. Fortunately, the driver saw the danger signal in time, and stopped his train. In the meantime efforts were being made to lift the engine of the passenger train on the metals. While this was going on, the 8.55 train from Manchester to Bowdon came up. The engine-driver perceived the signal, and accordingly moderated his speed to the utmost; but the distance between the end of the luggage train and his own was so short as to prevent him from bringing his train to a stand soon enough. It accordingly dashed into the luggage train, causing four of the trucks to be damaged almost beyond further use. The guard's box, although it was the last in the luggage train, was uninjured, except that the woodwork of the buffers was slightly cut and the iron a little bent. The Bowdon train consisted of eight or nine carriages. In the last carriage, a third-class, were several passengers, three of whom were injured. There were several other persons injured, but not seriously.

BOILER EXPLOSIONS.

Boiler Explosion.—An explosion recently occurred at Moorsley Colliery, belonging to the North Hetton Coal Company, in the county of Durham. The third of six boilers employed on the colliery burst, and was carried in four pieces high up in the air and over the tops of the pitmen's houses, to a distance of 200 to 300 yards. The bricks and broken steam pipes were scattered in all directions. The two firemen who were attending the boilers were killed, and a child who was sitting 60 yards from the seat of the explosion, also lost its life. The boiler which exploded was working at a pressure of 35lb. to the square inch.

Boiler Explosion at Liverpool.—On the morning of the 18th ult., just as the night and day relays of workmen were changing at the foundry of Messrs. Forrester and Co., Vauxhall-road, Liverpool, a large vertical boiler at the western end of the works, and close to the road, burst, hurling plates of the boiler, pieces of machinery, and brickwork in all directions. One portion came in contact with a large travelling crane, bringing a portion of it down, and crushing one of the workmen to death beneath the fragments. There were between 500 and 600 men on the works at the time, several who were near the boiler were severely scalded, and one of them died during the day. Others were fatally injured. The damage to property is estimated at from £1,000 to £1,500. The evidence given at the inquest will be found in another page.

DOCKS, HARBOURS, BRIDGES, &c.

Recent Improvements in Metallic Piers and Piles.—Mr. J. Phillips has just patented some improvements in piles or cylinders for piers, embankments, coffer-dams, and other structures that are wholly or partially under water. The invention relates to the means of rendering more or less perfectly watertight the vertical joints, interstices, or spaces existing between metal piles or cylinders employed for structures that are wholly or partially under water, and consists in forming grooves, recesses, shoulders, or flanges upon the contiguous sides of such piles, and then inserting into such grooves or recesses, or against such shoulders or flanges, pieces of wood or other suitable material, so formed that the pressure of the water causes them to fit tightly against one or more surfaces of the grooves, recesses, shoulders, or flanges of two contiguous piles or cylinders, thereby preventing the water from penetrating through the joints, interstices, or spaces between the two piles to the back of the same. It is preferred to make the grooves in the piles, and the pieces of wood to be inserted therein, of a rectangular form, and to form the lower extremity of the piece of wood with a double incline, so that when driven into the ground it is made of itself to press against the back surface of the two grooves and the side surface of one of them. In some cases the grooves and pieces of wood are formed so that when the latter are in their places, wedges or packing pieces may be inserted so as to press the piece of wood against the back surfaces, or back and side surfaces of the grooves independently of the action of the water, or the grooves and pieces of wood may themselves be made with inclined surfaces so as to produce a wedging action. In some cases the pieces of wood are compressed before inserting them into the grooves, so that when they come in contact with the water they swell out, and thus of themselves exert a pressure against the surface of the grooves. India-rubber, felt, or cork, in combination with iron, may be used in place of wood for forming watertight joints in the said structures.

MINES, METALLURGY, &c.

Coal and Iron in Scotland.—At the Institution of Mechanical Engineers, Mr. W. Moore, of Glasgow, read a paper "On the Principal Seams of Coal and Ironstone in the West of Scotland Coal Field." It stated that the valuable seams in the Glasgow coal field are situated in the counties of Lanark, Stirling, Dumbarton, Renfrew, and Linlithgow, and lie between the New Red Sandstone and the Hurlet coal. They are divided into upper and lower series of minerals. Those seams lying above the Garnkirk limestone of Garnkirk and Bedlay form the upper series, and those lying under the Possil and Cowglen limestone form the lower series. All the principal seams of ironstone under the Possil limestone are in the lower series. It is from the upper series that the coals have been taken for the supply of household, manufacturing, and iron smelting purposes, during almost the whole history of the coal field, and the upper seams in this series are collectively known as the Glasgow and Monkland seams, extending over an area comprising about 37 square miles more or less interrupted by faults. There are also several minor seams of coal in the upper series, which are, however, chiefly local, worked only in the immediate districts in which they are found. The main supply of ironstone for the use of the Scotch ironworks comes from the two Possil ironstones, the two Garscadden blackband ironstones, and the Paisley ironstone. The paper proceeded to give a variety of details with respect to the modes of working pursued in the different pits, and, in conclusion, presented the following statistics:—The whole Glasgow mineral district contains 111 blast-furnaces, producing about 900,000 tons of pig iron per annum, and consuming about 2,500,000 tons of coal, 1,134,000 tons of ironstone, and 445,000 tons of limestone. The entire district contains about 260 collieries, which raised annually about 8,500,000 tons of coal, or nearly 77 per cent. of the whole produce of Scotland.

GAS SUPPLY.

The Southampton Gas Company have announced a reduction in price to 4*s.* 6*d.* per 1,000 cubic feet.

The Taunton Gas Company have declared a dividend of 8 per cent. for the last year.

The Ludlow Gas Company have consented, at the instance of the consumers' committee, to reduce their price from 7*s.* to 6*s.*, with a discount of 6*d.* per 1,000ft. for payment in a month.

WATER SUPPLY.

Consumption of Water.—A man is generally supposed to require about $\frac{1}{2}$ gallon of water per day for drinking, cooking, &c., and about 4 gallons more for washing, bathing, and other purposes; a family of 5 heads will require about 9 gallons per day. In Paris, the consumption of this liquid is officially stated to be

$4\frac{1}{2}$ gallons for every man per day.
$16\frac{1}{2}$ " " horse "
9 " for a two-wheeled carriage per day.
$16\frac{1}{2}$ " " four " " "
92 " for every square yard of garden per annum.
66 " for a bath per day.
$\frac{1}{5}$ " for every square yard of public road per day.

The consumption in Madrid, according to the report of the directors of the Canal de Isabella II. Company, is

$5\frac{3}{4}$ gallons for every man per diem.
$21\frac{1}{2}$ " " horse "
$14\frac{1}{2}$ " " two-wheeled carriage per diem.
$21\frac{1}{2}$ " " four " "
12 " " square yard of garden "

The following is the consumption, in gallons, of water, per day and individual, in the chief towns of Europe and America:—Rome, 243; New York, 125; Marseilles, $103\frac{1}{2}$; Besancon, 54; Dijon, 44; Bordeaux, $37\frac{1}{2}$; Hamburg, 28; Genoa, $26\frac{1}{2}$; Madrid, 26; Glasgow, 25; London, $24\frac{1}{2}$; Cette, 23; Lyons, 19; Manchester, $18\frac{1}{2}$; Brussels, $17\frac{1}{2}$; Monaco, 17; Toulouse, $16\frac{1}{2}$; Geneva, $16\frac{1}{2}$; Narbonne, 16; Philadelphia, $15\frac{1}{2}$; Paris, 15; Grenoble, $14\frac{1}{2}$; Montpellier, 13; Nantes, 13; Voiron, 12; Clermont, 12; Edinburgh, 11; Havre, 10; Angouleme, 9; Liverpool, 6; Metz, $5\frac{1}{2}$; St. Etienne, $5\frac{1}{2}$; Altona, $5\frac{1}{2}$; Constantinople, $4\frac{1}{2}$; Rio de Janeiro, 2. This statement only comprises the quantities of water supplied by aqueducts; those yielded by wells and other means are not easy to ascertain.

Water Supply of Naples.—The authorities at Naples are about to introduce a new supply of water for the use of that city. Mr. Bateman has reported on the project, which it to cost £750,000. The water is to be conducted to a distance of 47 miles, and the quantity to be served per head of the population is 20 gallons per day. The present supply is about 8 gallons per day.

North Brazil Water Company.—A prospectus has been issued of the Ceará (North Brazil) Water Company, with a capital of £60,000 in shares of £10, to purchase and carry out a concession granted by the local government of the Brazilian province of Capitania, for supplying the city and port of Ceará with water at a stipulated tariff. The concession is for 50 years, and the price to be given for it is £10,000 in paid-up shares.

APPLIED CHEMISTRY.

A New Method of Producing Aldehydes, by M. Carstanjen.—The different processes for preparing aldehydes consist essentially in—1st. The oxidation of alcohols; 2nd. The oxidation of nitrogenised matters, such as albumen, gelatine, &c.; 3rd. The dry distillation of salts from fatty acids; 4th. The same distillation conducted with that of the formiates of lime and baryta; 5th. The distillation of albuminoid substances; 6th. The dehydration of glycols. On the strength of several observations, the author thinks himself justified in laying it down as a general fact that an aldehyde is always to be obtained by submitting an ammoniacal base to a proper oxidation. Among them is the acetic aldehyde $C_4H_4O_2$ rapidly developed when ethylamine is poured on crystallised permanganate of potash. At first violet, the liquid turns green, developes heat on shaking, becomes brown with effervescence, and finally evolves the aldehyde, so perceptible by its odour. The gas of the reaction passed into an ammoniacal solution of silver, promptly reduces it, forming a metallic silver mirror. With methylamine he has obtained a strongly reducing gaseous compound like the above, and, like it, capable of forming a crystalline compound with ammonia. He has not analysed it, but believes it to be the hitherto unfound aldehyde of methyle. With trimethylamine a compound is produced which the author believes to be identical or isomeric with propylamine.

Gun-Cotton.—Professor Abel, who has so carefully investigated the gun-cotton, thus sums up the peculiar properties of this explosive substance:—When inflamed, or raised to a temperature ranging between 137° and 150° centigrade, it burns with a bright flash and a large body of flame, unaccompanied by smoke, and leaves no appreciable residue. It is far more readily inflamed by powerful percussion than gunpowder; the compression of any particular portion of a mass of loose gun-cotton between rigid surfaces will prevent that part from burning when heat is applied. The products of combustion of gun-cotton redden litmus and contain nitric oxide, hence they have a corrosive action on gun-metal. In the open air it may be inflamed, when in actual contact with gunpowder, without igniting the latter; in a confined space (as in a shell, or the barrel of a gun) the almost instantaneous rapidity of its explosion produces effects which are highly destructive as compared with those of gunpowder, while the projectile force exerted by it is comparatively small. For these reasons Professor Abel—who is chemist to the War Department—does not think we are yet in a position to use gun-cotton as a substitute for powder.

The Chemical Constitution of Pig-Iron.—Herr Rammelsberg has recently investigated the views of Karsten and Gurlt on the chemical constitution of pig-iron, and has arrived at essentially different conclusions. According to Karsten, white and grey iron are chemical combinations of carbon with iron—the grey iron containing, at the same time, an admixture of graphite. This remains unchanged on the iron being dissolved in acids; while the chemically combined carbon—particularly with concentrated acids—is changed into a strongly odoriferous oil-like combination, the greater part of which volatilises in the hydrogen, only a small portion dissolving in the acid. According to their views, Spiegeleisen is a chemical combination of iron with the maximum amount of carbon, 5 to 6 per cent., but containing no graphite. Rammelsberg, on the contrary, has found 1·61 per cent. of graphite in the Musen Spiegeleisen; and Bromeis, before him, found graphite in the white pig-iron of Magdesprung, as will be seen by the following analysis:—

	Carbon in combination. Per cent.		Graphite Per cent.		Total. Per cent.
Bright white pig-iron	2·518	...	0·500	...	3·018
Grey pig-iron	2·908	...	0·550	...	3·458
Spiegeleisen	3·100	...	0·72	...	3·820

As, according to Rammelsberg, the Magdesprung Spiegeleisen only contains 3·9 per cent. of carbon, it seems that this class of iron may contain very unequal quantities of carbon, as well as an admixture of graphite, without any change in its character or properties. It might have been supposed that other metalloids replaced carbon—for example, silicon; but the analyses show, on the contrary, that the iron richest in carbon was also richest in silicon. In the Musen Spiegeleisen there was found 1·5 per cent. of silicon, in that of Magdesprung 0·17, and in that of Styria from 0·01 to 0·27 per cent., the latter only containing from 3·75 to 4·14 per cent. of carbon. According to Gurlt, Spiegeleisen is a fourth carbide, and octahedric crystalline grey pig-iron an eighth carbide; the phosphorous, sulphur, and silicon being isomorphous with the carbon, and the manganese with the iron. But if in stating the atomic ratio between the electro-positive and the electro-negative constituents of the Spiegeleisen of Musen and Magdesprung we adopt Rammelsberg's view, we have a ratio of 1 : 4·5 and 1 : 5·3 instead of 1 : 4. The grey octahedric crystals (the eighth carbide of Gurlt, approximating to wrought iron according to Tunner) are found to be very variable in composition, as shown by the following analysis:—

	From Rothehutte. By Rammelsberg.		From Lauchhammer. By Rammelsberg.		From Gleiwitz. By Gurlt.		From Lolling. By Richter.
Graphite	2·604	...	2·519	...	2·84	...	2 122
Carbon	0·201	...	0·373	...	2·46	...	0·967
Silicon	1·896	...	1·148	...	0·26	...	0·972
Phosphorus	0·065	...	0·406	...	?	...	0·021
Sulphu	0·069	...	0·043	...	?	...	0·008
Arsenic	—	...	—	...	—	...	0·005
Atomic ratio	1 : 19	...	1 : 21	...	1 : 8	...	12·5

Therefore there are generally more than eight atoms of iron to one atom of carbon (silicon, phosphorus). It will thus be seen that white as well as grey pig-iron may crystallise, under favourable circumstances, without the formation of the crystals being disturbed by the embedded graphite. The variation in the composition of the crystals shown by the above analyses—taking place without any alteration in the crystalline form—can only be accounted for by the isomorphism of the elements; and, according to Rammelsberg, such is the only possible explanation of the constitution of pig-iron. As all the essential constituents of pig-iron—such as iron, silicon, phosphorus, and carbon (as diamond)—crystallise on the regular system, and are consequently all isomorphous, we may consider pig-iron as an isomorphous mixture of its constituents, which will explain the variation of its composition. There are many examples of metals belonging to the regular system which form alloys that again crystallise on the same system; but there are also many alloys which crystallise on this system, whose constituent metals belong to distinct crystalline systems. On the other hand, metals that crystallise on the regular system form alloys crystallising on a different system; thus, for example, silver, zinc, nickel, and copper (iron), alloyed with antimony, crystallise on the pyramidal system. If, therefore, Spiegeleisen is pyramidal, as is probably the case, it belongs to this class of isomorphous mixtures, and the difference of form in grey and white pig-iron results from the heteromorphism of their isomorphous constituents. This heteromorphism is evidently a general characteristic of the elements, being just as marked in the metals as in sulphur and carbon: Doubtless the rhombohedric metals—Sb, As, Fe, Bi, Zn, Pd, Ir, and Rd—and the tetragonal Sn, isomorphous to Bo, may, under certain circumstances, crystallise on the regular system, while Au, Ag, Cu, Pb, &c., and also Sn, may be rhombohedric.

Respiration of Fruits.—M. Cahours has made an examination of the respiration of fruits; he considers that the fruit is one of the most important organs of vegetables, and that the examination of respiration should be by no means confined to the green part of the plant. He has endeavoured to study the proportion of gases contained in the parenchyma of the pericarp and their composition; the action of fruit upon the gas of respiration, *i.e.*, oxygen, whether alone or mixed with nitrogen; the action upon the same gas of each of the envelopes of the fruit and of its fleshy part when it exists. It was found that apples, oranges, citrons, in a state of maturity, placed under bell jars containing oxygen, or mixture of oxygen with nitrogen, consumed a quantity of oxygen, and furnished an equal amount of carbonic acid, the proportion being greater in diffuse light than in darkness. It is effected gradually up to a certain point, beyond which it augments considerably, and the internal face of the skin presents some alteration. The amount of carbonic acid produced increases with the temperature. The fruit acts in the same manner during the time elapsing between its losing its green colour and its obtaining its maturity, and that of its obtaining its maturity and of its commencement of decay; but as soon as this has once commenced the amount increases rapidly. Determinations were made of the proportions of gases contained in the juices. To accomplish this, the fruit was squeezed under mercury, and the juice collected in a flask, to which was afterwards adapted a tube by a cork, but it was found that the same result was obtained if the juices were expressed in an ordinary press and afterwards placed in vessels. The gases were expelled by ebullition. Oranges, citron, pomegranates, pears, and pippins gave quantities of gas diminishing in the order of the times; the gas consisted of carbonic acid and nitrogen in various proportions, but no oxygen, hydrogen, carbonic oxide, or carburretted hydrogen was found. A ripe fruit enclosed in air was found to absorb hydrogen very rapidly, and if allowed to remain until it became soft, the juice was found to contain a very large quantity of gas rich in carbonic acid, the air in which it was enclosed containing carbonic acid also. It is intended to examine the gases contained in the juice from the commencement of development to the time when it has attained its complete mercury.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of The Artizan."

Dated July 26th, 1864.

1853 G. Lansdown—Direct communication between guard and passengers in a railway train
1854 T. B. Heathorn—Submarine and other foundations
1855 T. Dixon—Sugar funnels or sugar moulds
1856 B. Britten—Projectiles for rifled ordnance
1857 H. A. Bonneville—Feed apparatus for steam boilers
1858 J. King—Signalling on railways
1859 F. L. Lyne—Appliance applicable to drinking vessels for the use of persons wearing moustaches
1860 J. H. Beattie—Construction of pumps
1861 A. Wydler—Drying woollen fabrics
1862 L. R. Bodmer—Self-acting mules
1863 G. Furness—Dredging or excavating machines
1864 W. Irwin—Preventing incrustations in boilers
1865 J. Slater—Bricks and tiles
1866 M. Scott—Ships or vessels
1867 A. Dalzell—Colouring matter applicable to dyeing and printing

Dated July 27th, 1864.

1868 W. Dicey—Communication between railway guards and passengers
1869 A. Alexander—Exploding missiles under water
1870 J. Olive, W. Olive, & E. Partington—Manufacture of paper
1871 J. A. P. MacBride—Raising sunken ships
1872—R. Couchman—Securing dress or other articles together
1873 W. Anderson—Moving parts of railway trucks
1874 V. Wanostrocht—Printing and perforating paper and fabrics
1875 J. P. Chambeyron—Preventing the oxydation of iron and steel
1876 J. P. Chambeyron—Manufacture of steel
1877 A. Prince—Cocks, taps, and valves
1878 C. W. Standish—Self-acting apparatus for closing or shutting windows

Dated July 28th, 1864.

1879 S. Hiley—Apparatus for finishing textile fabrics
1880 E. Brimson—Envelopes or covers for bottles and jars
1881 J. Newsome—Apparatus for breaking horses
1882 J. Livesey—Permanent way of railways and carriages for the same
1883 H. Moon—Washing clothes or fabrics

Dated July 29th, 1864.

1884 T. Moore—Tubular masts and spars, and in crutches for suspending ships' yards
1885 R. D. Sanders—Slide valves
1886 H. Freystadt—Hats, caps, bonnets, and other coverings for the head
1887 J. Cope—Fire-arms and ordnance for ascertaining the distance therefrom of objects to be fired at
1888 R. Redman & D. Kirkwood—Breechloading fire-arms
1889 J. Nicklin—Hooks to be used for the suspension of curtains
1890 W. Anderton—Preparing, spinning, and doubling fibrous substances
1891 P. E. Fontenay—Pocket perfume fountain
1892 E. B. Wilson & C. De Bergue—Furnaces
1893 J. Long—Stopping or retarding railway and other carriages

Dated July 30th, 1864.

1894 H. McEvoy—Articles used in the games of croquet
1895 T. Wilson—Fire-arms
1896 H. J. Distin—Cornets and other musical wind instruments
1897 J. F. Hearsey—Measuring liquids
1898 G. A. Huddart—Covered buttons
1899 E. Schischkar & C. G. Speyer—Yarn for Knickerbocker tissues
1900 W. Payton—Supporting hats when not in use
1901 T. Bourne—Rollers for cotton gins and other machines
1902 A. Kistemann—Burners applicable to lamps in which petroleum is used.
1903 G. Carter—Caps for the chimneys of dwelling-houses
1904 F. E. B. Beaumont—Machinery for driving drifts or galleries through rock

Dated August 1st, 1864.

1905 P. H. Moore—Adjusting the load contained in a drag to the back of a horse
1906 E. Tattersall—Communications in railways between passengers and guard
1907 R. A. Brooman—Manufacture of artificial fuel, and in machinery for moulding or compressing the same
1908 C. Eastwood—Sweeping the platforms of railway stations
1909 J. Everard—Rollers of window blinds
1910 W. Pearson—Reefing sails
1911 P. C. Sisse—Shanks for fancy buttons of hard materials
1912 H. Attwood—Packing and lubricating parts of steam engines
1913 H. Cutler—Green colouring matters

Dated August 2nd, 1864.

1914 H. T. Davis—Affixing postage stamps and non adhesive labels
1915 T. Newby—Self-closing doors
1916 F. D. Delf—Coating fabrics with medical or other compounds
1917 R. Kay—Rollers employed in apparatus for preparing cotton
1918 C. Hochgesangt—Crinolines
1919 F. W. Bossert—Albums, ladies' companions, or work cases
1920 J. H. Johnson—Glazes or enamels for pottery-ware
1921 S. Hawksworth—Floor cloth
1922 W. Barber—Stiffening or proofing felt or other hats
1923 A. Smith—Sewing machines
1924 M. Woodifield—Communication between passengers and guards and between guards and engine drivers

Dated August 3rd, 1864.

1925 J. H. Johnson—Propelling ships
1926 E. Brasier—Breaking fibrous materials
1927 E. Warry—Apparatus for breaking and stamping flax
1928 W. E. Gedge—Fabric call d Foulardine
1929 W. T. W. Jones—Apparatus to enable passengers to signal to the guard of a train
1930 P. G. B. Westmacott—Hydraulic cranes
1931 C. Garton—Mashing apparatus
1932 A. L. Wood—Sewing machines
1933 A. Bain—Drawing-off liquids
1934 C. Bolton—Sewing machines
1935 E. Cook—Metallic bedsteads, and other articles of like manufacture
1936 W. Procktor—Portable stoves

Dated August 4th, 1864.

1937 B. O'Connor—Making non-inflammable cotton fabrics
1938 M. A. Saul—Fastenings for railway rails, applicable to other purposes.
1939 T. J. V. Rox—Pianofortes, and keyboards for similar instruments
1940 G. E. M. Gerard—Cutting sheets of india rubber into threads
1941 F. Cruickshank—Coatings for the prevention of the fouling of ships' bottoms
1942 J. Radcliffe—Narrow fabrics
1943 A. Guthrie & T. Tracey—Machinery for preparing cane
1944 A. Long—Apparatus to facilitate the acquisition of languages
1945 J. Gothard—Construction of furnace bars of furnaces
1946 G. E. Druce—Anchors
1947 F. Thornton—Presses for pressing and packing cotton
1948 F. J. Bramwell—Nuts for screw bolts and such like articles
1949 A. H. A. Pflughaupt—Producing colour from aniline
1950 G. F. Marchisio—Generating inflammable air for illuminating and heating purposes

Dated August 5th, 1864.

1951 J. Heydon—Moulds in which metals are to be cast
1952 J. Lee—Preparing leather for mill straps or driving belts, and in the manufacture of such articles
1953 I. Farrell—Railway carriages
1954 M. Henry—Cylinders, pipes, tubes, and similar

Dated August 6th, 1864.

1955 W. R. Taylor—Casks for wine and spirit
1956 G. Leyshon—Tin and terne plates
1957 E. Hottin—Rendering uninflammable cotton textile fabrics
1958 W. Stott—Army cloths
1959 R. Edmondson—Healds for weaving
1960 C. W. Laucaster—Projectiles
1961 C. P. Coles—Ships of war
1962 C. Bartly—Preventing the bottoms of iron ships from fouling
1963 N. McHaffie—Iron plates for shipbuilding and similar uses
1964 W. Brookes—Furnaces to facilitate the consumption of smoke
1965 S. L. Cousins—Construction and propulsion of boats

Dated August 8th, 1864.

1966 G. A. Nowell—Pumping water
1967 W. Collins—Breech-loading fire-arms
1968 M. Runkeli—Automatical regulator for marine engines
1969 W. E. Gedge—Caster
1970 J. H. John—Cooking eggs
1971 L. Young—Cocks for supplying water
1972 J. Lessware—Ball valves for drawing off condensed water
1973 P. A. J. Dujardin—Electric telegraphs

Dated August 9th, 1864.

1974 Communication between passengers and guard of a railway train
1975 E. Crook & F. Crook—Construction of brackets for supporting banner screens, reading desks, and other articles
1976 D. Speirs, A. Boyd, J. Aitken, & M. Gilmour—Looms for weaving
1977 W. Richards—Measuring the passage of liquids, and in apparatus employed therein
1978 M. Payne—Traction engine
1979 A. Turner—Communication between passengers and guard
1980 J. L. Norton & W. Ainsworth—Looms for weaving
1981 W. Clark—Ornamentation on porcelain, and other surfaces
1982 W. Clark—India rubber balls and other elastic recipients

Dated August 10th, 1864.

1983 J. Pratt—Typograph, or type-writing machine for reporting
1984 W. Mason—Machinery for cleaning cotton or other seeds
1985 J. Grice—Folding carriage-steps
1986 G. Davies—Steam boilers
1987 G. Haseltine—Spring tension regulator
1988 H. Armistead—Sizeing or preparing warps for weaving
1989 J. H. Johnson—Gilding glass and vitreous substances
1990 R. Pepper & A. Barr—Passenger safety signal for railway carriages
1991 R. Danautt—Cultivating land
1992 R. A. Brooman—Lever machines for obtaining and applying motive power
1993 B. H. Mathew—Fire-arms and ordnance, and in cartridges
1994 C. Lowe—Colouring matters

Dated August 11th, 1864.

1995 J. Russell—Rimming, widening, or fairing rivet holes
1996 R. D. Edwards—Cleansing and treating cotton seeds
1997 J. Lang—Securing rails on the permanent way of railways
1998 A. B. Childs—Mowing machine.
1999 A. V. Newton—Manufacture of printing type
2000 J. Milbank—Heating conservatories and other buildings
2001 R. A. Brooman—Producing luminous placards, signals, and advertisements
2002 P. Lang—Knife for cutting the clamps of boots and shoes
2003 J. Adam & J. Webb—Application and in the preparation of certain fibres for the production of paper
2004 S. C. Hemming—Permanent way of railways

Dated August 12th, 1864.

2005 H. Pether—Construction of arches, floors, or pavements
2006 W. Brenton—Reaping machines
2007 A. Alison—Raising water and minerals from collieries
2008 G. Haseltine—Churns
2009 H. Dyer—Chimney tops and ventilators, and apparatus for cleaning the same
2010 G. Davies—Sewing machines
2011 A. H. Williams—Holder for cartridges
2012 M. Brown—Washing and cleansing yarns, woven fabrics, also applicable for milling woven fabrics
2013 J. P. Lindsay—Locks for fire arms
2014 M. Peck—Patched balls for fire arms

Dated August 13th, 1864.

2015 J. H. Huxley—Projectiles
2016 H. C. Tucker—Chimney-pieces
2017 W. Jones—Presses for stamping or embossing paper
2018 E. Andries—Purifying every kind of water and rendering it drinkable, and for rendering sea water fresh and drinkable
2019 W. Richardson—Rollers for cotton gins
2020 G. Bedson—Twisting wire for fencing other purposes
2021 J. B. Buffoni—Bracelets, and other articles of jewellery
2022 J. Hodgart—Presses for pressing cotton and other substances
2023 J. Dilkes & E. Turner—Facilitating communications between passengers and drivers in railway trains
2024 W. H. Cox—Guns
2025 A. C. Pilliner & J. C. Hill—Obtaining motive power applicable to measuring, raising, and forcing fluids
2026 R. T. Monteith—Preserving eggs
2027 R. Cordner—Railway sleeper

Dated August 15th, 1864.

2028 A. B. Childs—Machines for ploughing or cultivating land
2029 S. Moore—Electro-gilding
2030 R. A. Brooman—Aerostatic machine
2031 R. A. Brooman—Cast steel
2032 S. Collins & C. Collins—Silk floss, adapted for being woven and spun into articles of use
2033 E. A. Pontifex—Treating stick lac when manufacturing shell lac
2034 W. Hoehl, C. Brakell, and W. Gunther—Machinery for opening, cleaning, and ginning cotton

Dated August 16th, 1864.

2035 T. Morgan—Communication in railway trains between passenger and guard and guard and engine driver
2036 W. Yule—Rolling mills and in couplings for the same
2037 W. Dove—Water marks in paper
2038 W. Milligan—Communicating motion from one railway carriage to another
2039 C. F. Durcagne—Preparing the sorgho plants to render the same applicable to the purposes of manufacture
2040 A. V. Newton—Sewing machinery
2041 B. B. Storey—Construction of submarine works and in the apparatus to be employed therein

Dated August 24th, 1864.

2042 G. Hodgson—Hand drilling apparatus, adaptable also as a vice
2043 P. A. L. de Fontainemoreau—Preserving animal and vegetable alimentary substances
2044 W. Dalziel—Regulating the pressure and supply of gas
2045 T. Turner—Communication between one part of a railway train and another
2046 G. Coles & J. A. Fanshawe—Tubular and other hollow articles

Dated August 18th, 1864.

2047 T. P. Tregaskis—Magnets for overbalancing weights
2048 T. Wilson—Breech-loading fire-arms, and converting breech loading into muzzle-loading fire-arms
2049 W. Clark—Communication between passengers and guard, or otherwise, and for operating the brakes
2050 J. J. Parkes—Application of gas and other fluids for lighting
2051 L. Y. Laurent—Military outfit for soldiers in campaign
2052 C. Cotton—Communication of passengers from carriage to carriage
2053 W. Thomas—Communication between passengers and guard
2054 F. Swift—Axles and axle-boxes
2055 J. C. Desumeur—Spring mattress

Dated August 19th, 1864.]

2056 J. Grantham—Machinery used in manufacturing compressed fuel
2057 E. H. Waldenstrom—Manufacture of metallic nuts
2058 C. E. Albrecht—Admission, exclusion, and regulation of gas
2059 B. Burton—Breech-loading and revolving arms fire-arms
2060 H. Parkes—Colours for dyeing, printing, and other uses
2061 F. G. Underhay and R. Heyworth—Supply of water to water closets
2062 F. Krenz—Crinolines, and such like articles of wearing apparel
2063 J. Thomsen—Generating electricity

Dated August 20th, 1864.

2064 G. Davies—Submarine shells, and apparatus for operating the same
2065 J. G. White—Mechanical arrangements for propelling ships
2066 J. Hartshorn—Manufacture of fabric in lace machinery
2067 J. Walker—Mounting, working, and covering guns
2068 F. Feichtinger—Preventing damp, insects, and vermin, from entering dwelling houses
2069 H. Wilson—Water-closets, also applicable to ships' scuppers
2070 W. E. Gedge—Overcoat
2071 C. W. Harrison—Looms for weaving
2072 F. Taylor—Receiving and deodorising human excrement
2073 J. Allan—Adhesive mixture

Dated August 23rd, 1864.]

2074 B. W. Barwick and W. Hartley—Spinning machinery
2075 T. Wray—Communication between passengers, guards, and engine drivers
2076 G. G. Boggio—Extracting the oil contained in the flour of oleaginous seeds for distilling volatile substances
2077 R. M. Black—Screw keys
2078 T. H. Cleveland—Signalling between passengers and guards or other persons in charge of railway trains
2079 J. E. Grisdale—Photometric prints
2080 R. A. Brooman—Winding, unwinding, and and paying out telegraphic cables, applicable also to winding and unwinding ropes
2081 D. S. Brown—Lint
2082 G. Parsons—Breaking flax, and crushing agricultural produce

Dated August 24th, 1864.

2083 J. S. Farmer—Railway signals, and in means of signalling between passengers and guards of railway trains
2084 A. Ford—Floor cloth
2085 S. Sharp & A. Double—High pressure non-leakage tap
2086 W. Spence—Raising and discharging water
2087 H. Greaves—Apparatus for lauding passengers and merchandise
2088 A. A. L. P. Cochrane—Heating and evaporating fluids
2089 E. Taylor & W. J. Dorning—Stop cocks, taps, or valves to be employed in connection with hydraulic pumps and presses
2090 J. M. Steinbach—Sewing machine
2091 W. H. Baruicoat & D. Barr—Portable fruit dressing machine for cleaning and removing the stalks and dirt from currants
2092 R. Pilkington—Gas burners
2093 H. L. Kozawsky, R. Hart, and J. F. Calder—Preparation of jute
2094 J. Matthews—Retarding and stopping trains on railways
2095 R. Beard & W. Downing—Artificial leather, and in colouring, dyeing, or finishing the same, which latter improvements are also applicable to dyeing ordinary leather cloth

Dated August 25th, 1864.

2096 T. J. Hughes—Coating and sheathing ships bottoms
2097 H. Potter—Bleaching fibrous substances
2098 W. Cope—Bobbin carriages used in lace machinery
2099 N. J. Peton—Machine for sweeping chimneys
2100 R. A. Brooman—Lighting and firing charges in mines
2101 G. Davies—Filter presses
2102 G. H. Cottam & H. R. Cottam—Transferring railway carriages from one line of rails to another, and in apparatus used for lifting and adjusting rails of railways.
2103 A. Newton—Receiving or holding clothes or other articles

Fig. 1. Elevation.

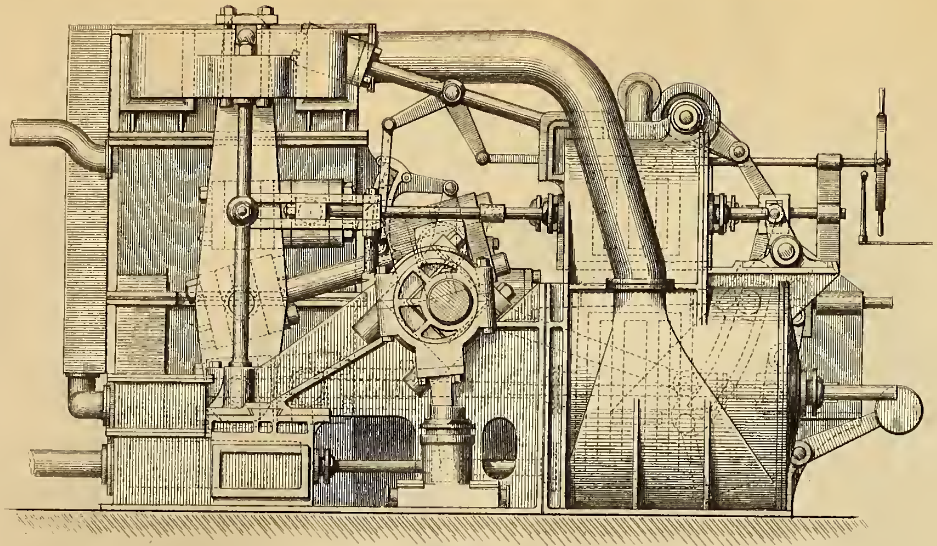
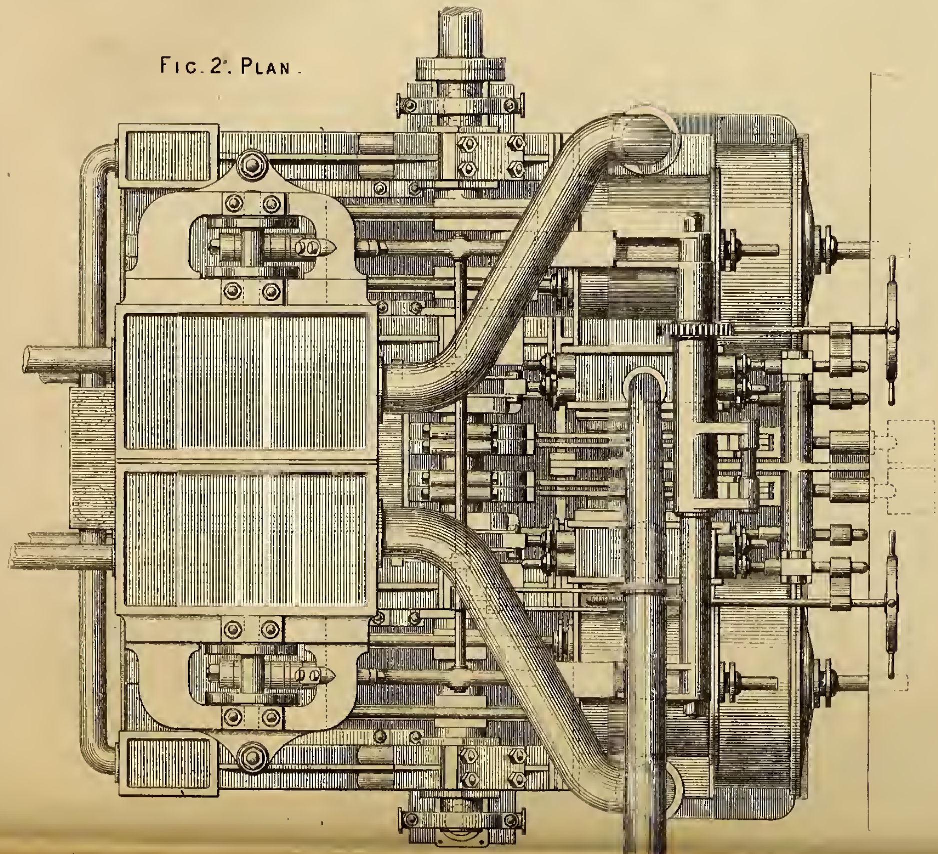
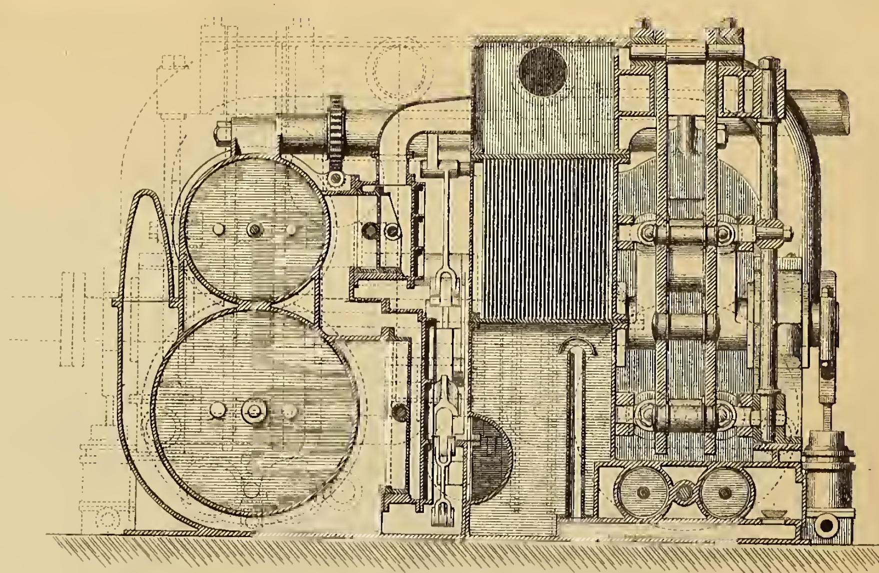


Fig. 2. Plan.





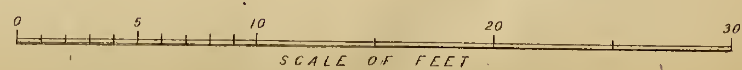
Section thro' Cylinders. Section thro' Condenser.

Fig. 3.

1000 HP. HORIZONTAL ENGINE,

DESIGNED BY F. W. WYMER, *ENGINEER*.

NEWCASTLE-ON-TYNE.



THE ARTIZAN.

No. 22.—Vol. 2.—Third Series.

OCTOBER 1st, 1864.

F. W. WYMER'S HIGH AND LOW PRESSURE ENGINES.

(*Illustrated by Plate* 268.)

In The Artizan of July last we referred to the features in Mr. Wymer's arrangement of high and low pressure engines, and we illustrated our article by a plate of a pair of inverted screw engines, of 250 nominal horse-power, according to Mr. Wymer's plan.

The accompanying Plate 268 illustrates the arrangement of horizontal engines also upon Mr. Wymer's plan, such as he proposes for use in war vessels, with a view to economise height and space. The high pressure cylinder is shown as being placed above the expanding cylinder, the two piston-rods of each cylinder being connected (as in the vertical engines illustrated in our July number) by cross-heads and links to a beam, vibrating on an axis supported at the sides of condensers, from which beam the connecting-rod returns to the cranks of the main shaft.

The air, cold water, and feed pumps are shown as being worked by a piston-rod direct from the piston below the centre of cylinder. The bilge pumps are worked by eccentrics at the extremity of engines. The steam is regulated at the high pressure cylinder by a sepaarte expansion valve with a variable cut-off.

The following are the dimensions and general particulars of the engines.

Number of cylinders	4
Diameter of high pressure cylinders	5ft. 11in.
Stroke of do.	3ft.
Diameter of expanding do.	8ft. 4in.
Stroke of do. do.	6ft.
Length of crank	2ft. 3in.
Length of connecting-rod	9ft.
Diameter of air-pump	2ft.
Stroke of do.	6ft.
Diameter of cold water pump	2ft.
Stroke of do.	6ft.
Diameter of screw	24ft.
Do. of paddles (if side wheels)	24ft.
Number of revolutions per minute with full steam high pressure cylinders	60 revolutions.

In the accompanying Plate, Fig. 1 is an elevation of a horizontal engine, of 1,000 horse-power, according to this arrangement; Fig. 2, a plan; Fig. 3 being a sectional elevational view, one-half of which is a section through the cylinders, and the other half being a section through the condenser.

HISTORICAL AND DESCRIPTIVE SKETCH OF THE MERSEY DOCKS AND HARBOUR.

By J. J. Birckel.

(*Illustrated by Plates* 269 *and* 270*.)

The results of Captain Denham's observations on the tidal currents in the estuary of the Mersey, and the substance of his experience respecting the accumulations of deposit within it and in the bay outside, as embodied in our last paper, forcibly direct the mind towards the two following main conclusions, namely :—

1st. That, as matters stood when Captain Denham wrote, the course of the navigable channels was liable to great and rapid changes, demanding constant watchfulness in order to ensure safety to the navigation of the port; and

* These plates will be given next month.

2nd. That the quantity of matter held in suspension by the waters of the ebb tide, and by them deposited into the lower estuary and the bay, was so considerable as to render it a matter of certainty that the approaches to the port would be sufficiently blocked up at no distant period of time, to seriously damage its commercial importance, unless judicious and timely means were adopted to counteract that evil.

With regard to the last-named conclusion, it may at once be observed that if it held good in 1838—that is, if the experiments made by Captain Denham to ascertain the respective quantities of matter held in suspension by the flood and ebb waters, and indirectly by the waters brought down from inland by the various streams which discharge themselves into the estuary, were correct—then there can be little doubt that the same conclusion holds good now, since the primary cause of this evil must have increased rather than diminished during the time which has intervened, by the increase in numbers and in copiousness of some of the main sources of this pollution of inland streams, such as the influx of the sewage of towns and of the refuse of manufactories placed along their banks or within their drainage area. But one of the facts mentioned by Captain Denham to illustrate the magnitude and rapidity of the changes which may take place in the navigable area of the estuary, namely the fact that the mooring ground of the Lazarets shoaled up 33ft. in eight years, and that the deposit thus formed, amounting to the enormous bulk of 2,285,000 cubic yards, was removed by tidal action alone within the space of two years, relieves the mind considerably of the anxiety created by the gloomy forebodings respecting the future of the port, shadowed forth by the general conclusion last named; since, reasoning from analogy, the hope is thus to some extent justified that the same cause which wrought such remarkable changes formerly may be at work still both inside and outside the estuary, and may again bring about similar results.

Yet does this consideration not by any means justify the conclusion that the estuary and its approaches will take care of themselves, and that Captain Denham's exhortation to watchfulness was but the manifestation of an over anxiety of mind not justified by facts. Against such a conclusion the result of his exploration of the banks outside, as detailed in our last paper, speaks convincingly enough; and unless the correctness of his observations be impugned or entirely discredited, that exhortation must continue to stand a faithful guide to the mariner who frequents this port, and to the merchant who entrusts his property to the skill and care of the former, notwithstanding an opinion expressed, some seven years ago, by Mr. Graham Hills, the present assistant marine surveyor, that—" The amount of change to which the general features of the accumulations have been subject throughout the period of hydrographic record are but small." An opinion which, we venture think, he would not now express, after having explored those accumulations for a period of eight years, and during that time recorded considerable changes in his own surveys.

It is no doubt true enough, as has been written by the same gentleman, that—" The first light of history dawning upon the scene presents to our view the same natural features which now we witness," in so far as that remark applies to the high water out-line; for, in any bay or estuary margined generally by low shelving shores, and subject to a tidal rise and fall of upwards of 30ft., it must require long periods of time to change their general aspect to any considerable extent by the mere ordinary causes of tidal and atmospheric action; and nothing short of a great convulsion, such as it is now taught by geologists has not taken place during the historic period

of the earth's existence, would work any such change of sufficient magnitude to be discernible at a single glance.

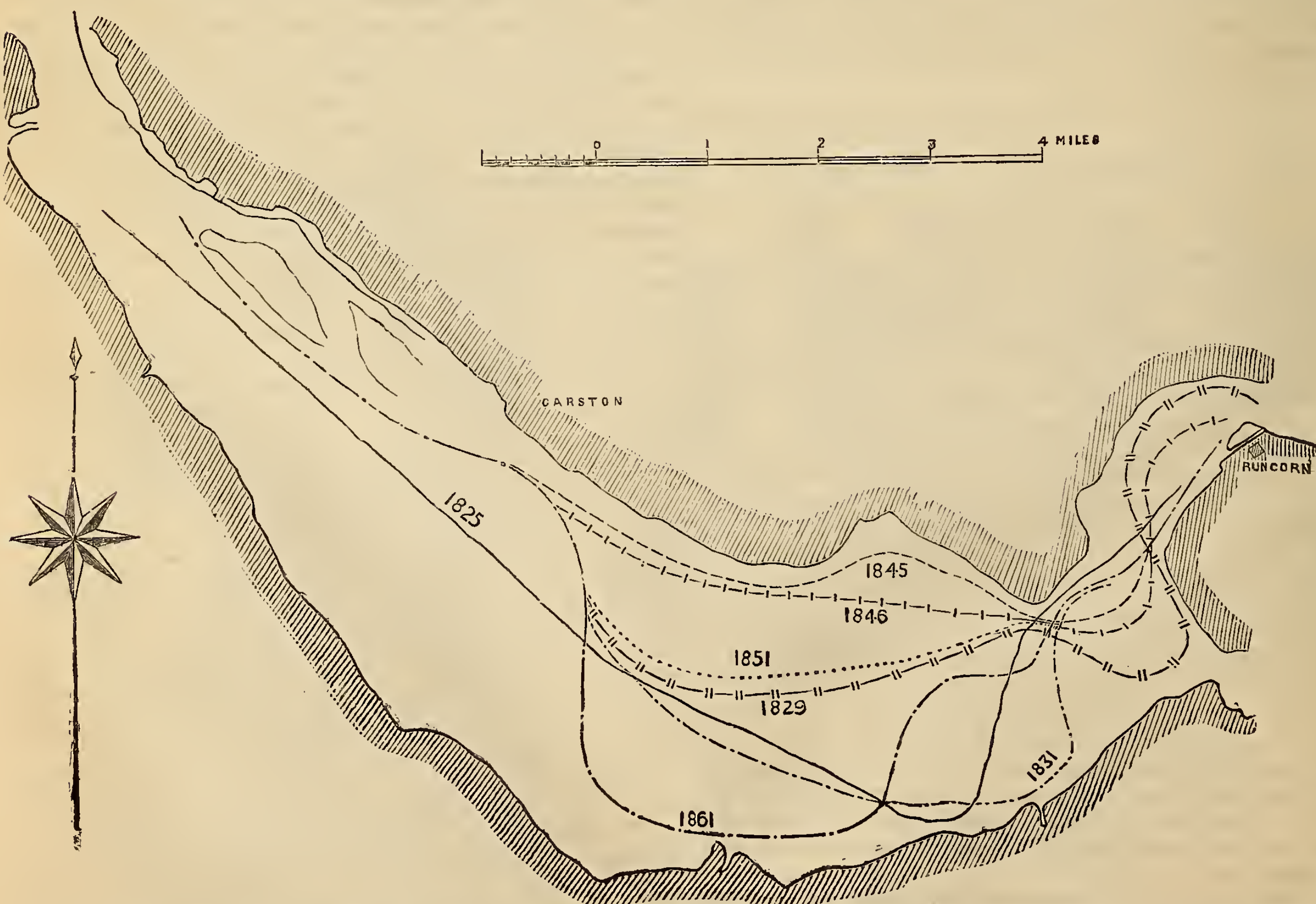
So stationary have the high water features of the upper estuary of the Mersey remained, that the Bridgewater Trust, who are in possession of the navigation of that portion of the river, have, up to the present date, taken Captain Denham's survey as the working basis of their charts; and it was not until 1860 that the Mersey Docks and Harbour Board had the river surveyed within its tidal area in order to define the limits of the conservancy jurisdiction over the Mersey. According to this survey, by Lieut. Murray T. Parkes, R.N., the tidal area amounted then to 22,274 statute acres upon a tide rising 21ft. above the datum of the old dock sill, which corresponds to a total range of 31ft.; whereas from Captain Denham's surveys, in 1836, it was computed at 23,062 statute acres. Taking into account the abstractions which had in the intervening time been made in the estuary below for dock purposes to the amount of 620 acres, it may be said that the tidal area has remained unchanged during a period of 25 years.

It is true also that the high water line is now defined over the greater portion of its extent on both shores by artificial works of a permanent character, such as walls and embankments, as may be seen from the schedule annexed, quoted from a report by Lieutenant Parkes to the Dock Board consequent upon his survey. There is, however, little ground to suppose that any considerable change had taken place previous to the construction of this permanent high water line, whose tendency undoubtedly is to render the extent of tidal area permanent in a similar degree; for, although the shores which remain as yet unprotected by artificial works are subject to frequent abrasions, yet are these on the whole very limited in extent, and compensated sometimes by corresponding deposits elsewhere, which cause continuous changes in the minute details of the outline, without producing any alteration in the general aspect.

SCHEDULE DESCRIPTIVE OF THE HIGH WATER LINE OF THE TIDAL EXTENT OF THE RIVER MERSEY IN 1860.

Distinguishing Features.	Lancashire.	Cheshire.	Total.
NATURAL.	Miles.	Miles.	Miles.
Rocky Cliffs	0·4	3·4	3·8
Soft Clay ditto	7·6	4·6	12·2
Low Shelving Shores	3·8	4·5	8·3
ARTIFICIAL.			
Wall	12·0	10·0	22·0
Embankments, Rubble-faced	0·75	5·4	6·15
Ditto Loose Earth or Sods	8·8	13·0	21·8
Total	33·35	40·9	74·25

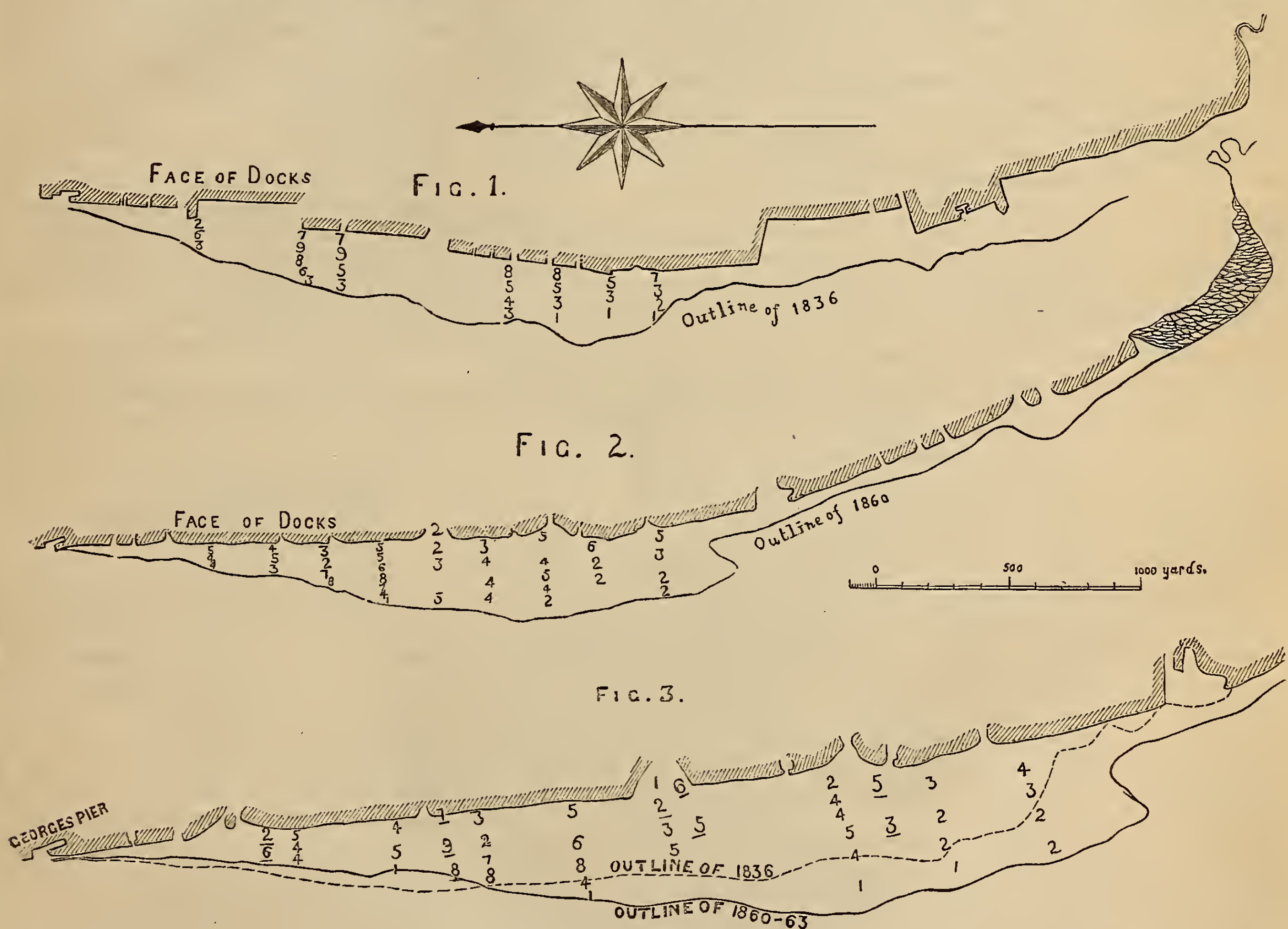
The difference by which the tidal area is affected in the variation between high spring tides and short neaps is about 1,500 acres, which assume the character of low marsh land, available to a great extent for grazing purposes during the period of the short tides; but with regard to their



PLAN OF THE RIVER MERSEY BETWEEN RUNCORN AND LIVERPOOL, SHOWING THE POSITION OF THE NAVIGABLE CHANNEL AT VARIOUS PERIODS.
(From the Surveys of Captain Foulkes, of the Bridgewater Trust.)

ontline, and the low water features generally of that portion, at any rate, of the estuary which is navigable by sea-going vessels, nothing that has beeu quoted from the writings and experience of Captain Denham respecting their sportive and transitory nature could give au adequate idea of the extent of this sportiveness, and of the rapidity with which changes of considerable magnitude do take place.

Upon the accompanying enlarged plate engraving of the tidal extent of the river, upon which the entire marine establishment of the Bridgewater Trust is shown in detail, aud for which we are indebted to the kindness of Mr. Fereday Smith, the secretary to the trust, thc high-water line is, in the main, taken from Captain Denham's survey (as has been previously stated), and the low-watcr features are taken from the surveys of Captain Foulkes, whose duty it is daily to buoy the channel, aud to issue instructions which shall enable masters of vessels to run up safely from Liverpool to Runcorn. Upon his authority, and, through his kindness, from our own ohservations, we are able to state that the course of this channel does not remain two days alike; and the changes occurring within the period of one month are so considerable, that he finds it necessary to lay down a new chart every month. Thus, upon the plate referred to, the course of the channel in May, 1863, was as shown in full outline; but in February, 1864, it had shifted to the outline in dotted line, which shows it scouring away the pasture land between Ince Hall and Stanlaw Poiut, and, lower down, breaking through Offing bank and Eastham Sands; and in May following we find it, as shown in our plate, encroaching further still upon the pasture land below Ince Hall, while the channel had clearly established itself across South Offing, and broken through North Offing bank,



uniting the southern portion of the same with the Eastham Sands. The accompanying wood engraving also illustrates generally the course of the navigable channel at various periods, from 1825 down to this date, and shows that it has shifted from one shore of the estuary to the other, and taken the most unlikely detours, without any accountable order of succession whatsoever. The general conclusion to be drawn from the fact thus illustated appears to be, that in a tidal river like the Mersey, with a narrow mouth widening into a broad lake, which hrings down a small volume of water from inland only, and which is snbjcct to a tidal fall that sets its bed almost dry at low water, the course of the navigable channel is subject to constant changes, the directiou aud extent of which it is impossihle to predict, and the ouly means to ensure safety to the navigation is to survey that channel daily,—any attempt to render it permanent would end iu total failure. Such were the conclusions drawn by Mr. J. F. Bateman when, some time ago, the managers of the Bridgewater Trust, desirous, if possible, to obtain a permanent channel, had recourse to his advice. One observation worthy of special notice was made by Captain Foulkes in the course of his surveys, namely, that a depth of channel of from 2ft. to 4ft. only, at low water, has been obtained where its course lay across two sandbanks; but wherever it touched the shore, depths of from 12ft. to 14ft. were sometimes ohtained.

Taking now into consideration the capacity of the estuary in its entirety, it will be remembered, from the extracts given in our second paper, that Messrs. Whidby, Rennie, and Giles, in their several reports, recommended the construction of river walls in its lower portion, in order to guide the tide and to prevent the loss of impetus through friction and impact

against an uneven shore; we have shown, also, that Captain Denham recommended the construction of a wall between Dingle Point and Otterspool, chiefly to prevent the extension of Pluckington Bank, but also to check the growth of Devil's Bank; and Mr. Rendel, the father of the Birkenhead Docks, gave it as his opinion that the extension of the walls on both sides of the river would be beneficial to the harbour, these recommendations all being based on the assumption that by guiding the tide a better scour would be obtained. Since then a considerable length of wall has been built, at Birkenhead and at Liverpool, the river wall proper has been carried several miles to the northward; in which direction, also, it may here be stated, almost all dock extensions have taken place, for the simple and very tangible reason that the land having to be bought, and the expense of a wall having to be incurred for purposes of conservancy, it was sound economy to occupy that ground by works, which being absolutely wanted somewhere for the accommodation of the trade of the port, would pay an interest at least on the capital expended upon the primary object to be attained. Such having been the advice tendered by the profession at various times with regard to the conservancy and improvement of this harbour, it may now be interesting to them to learn how far their anticipations have been realised, and whether the accumulations of sediment in the estuary have been lessened, since a portion, at least, of the works recommended by them have been carried out. As to this point we have been informed by Captain Foulkes, to whose care the navigation of the upper estuary has for many years been committed by the managers of Bridgewater Trust, and who, having spent some thirty-five years of his life upon this river, is better qualified than anybody else to give testimony as to its present and former condition. By him we are informed that whereas in the earlier days of his career, no ships exceeding 250 tons burthen would be taken up to Runcorn; now they are able to take up ships of from 400 to 500 tons burthen, drawing as much as 15ft. of water, and that generally there is a greater depth of water in the river than formerly; we have seen, also, that in 1840 Captain Denham spoke of an *eleven* feet of low water outlet to the harbour, whereas now the soundings of Lieutenant Murray T. Parkes indicate depths of from 14ft. to 16ft. of water upon the bar at low water spring tides. In presence of these facts, it being known, also, that the height of the tidal wave had remained unchanged, the logical inference is that an efficient scour of the tide has been attained already, whereby considerable portions of deposit have been removed. Upon comparing Captain Denham's survey of the estuary between the Rock lighthouse and Garston, which we have reproduced on an enlarged scale upon Plate 269 for the special purpose of comparison, with the survey already referred to upon Plate 267, it is seen at a single glance that the deposits known as *Devil's Bank* and *Garston Sands* have been considerably reduced, and we are able to state, on the authority of Captain Foulkes, that upwards of 20ft. of solid bank have been scoured away on that spot, at the same time, however, the North Offing Bank has formed to the northward of Eastham Sands.

The only accumulation which has so far evinced a character of permanency, that fully justifies the anxiety with which Capt. Denham watched its growth, is Pluckington Bank. In the accompanying woodcuts (Figs. 1, 2, and 3), we have produced the outlines of that bank as it stands at present, according to the surveys of Lieutenant Parkes, and as it stood in 1836, when Captain Denham surveyed it; and from these diagrams it may be ascertained that, while it has slightly receded at its northern tail, it has extended considerably southward, and has spread as much as 400ft. further into the river. It does not appear, however, to have grown so much in height as we believed, before we had carefully examined the soundings, and even seems to have slightly diminished at its northern extremity.

The changes thus noted in the height and outline of this bank seem to us sufficiently important to invite explanation, and this, we believe, can be offered satisfactorily, only in the following manner:—The abrasion at the northern extremity appears to be due to the action of the flood tide, which seems to be less deflected to the westward, since the partial reclamation of Wallasey Pool, and since the prolongation of the river wall to the northward on the Liverpool shore; and, its extension southward and westward into the middle of the river must be accounted for by the deflection of the ebb tide at Dingle Point, as was shown by Captain Denham, causing so great an eddy immediately below that point as to give time to the slack waters to deposit the solid matter which they contain in suspension, with greater rapidity than opposite causes are able to remove them. These features in the history of Pluckington Bank appear to us to confirm in so remarkable a manner the views of Captain Denham respecting this deposit, that we feel called upon especially to impress the fact upon our readers, because it will convey to their minds a correct idea of that officer's merits as an accurate observer of natural phenomena. They seem to indicate also that Pluckington is not only a permanent, but a permanently growing evil, which, while it *now* greatly inconveniences the shipping that seeks shelter and accommodation in the Southern Docks, threatens those docks with almost total obstruction at no distant future; and we believe on that ground that the conservative works of this harbour must be regarded as incomplete so long as the river wall is not extended from Dingle Point to Otterspool, according to Capt. Denham's suggestion.

The following tables are here given in further explanation of plate No. 265:—

MERSEY DOCKS AND HARBOUR.

Tabular Statements showing the Area of Water, Quay Space, Width of Entrance, and Depth of Sill, also the Length of Graving Docks, &c.

The Level of the Old Dock Sill is the Datum to which the Depth of Sills refer, and is preserved on a Tide Guage at the west side of the Centre Pier of the entrances to the Canning Half-Tide Dock.

The Old Dock contained an area of 3 acres 1890 yards, and 557 lineal yards quay space.

Its Passage contained an area of 675 yards, and 90 lineal yards quay space.

LIVERPOOL DOCKS.	Width of Entrance.		Sill under Old Dock Datum.		Coping at Hollow Quoins above Sill.		Water Area.		Quay Space.	
	ft.	in.	ft.	in.	ft.	in.	Acr.	Yd.	Mile	Yd.
North Carrier's Dock, West Passage	40	0	6	0	33	0	2	3423	0	641
South Ditto ... West Passage	40	0	6	0	33	0	1	4515	0	615
Canada Half-tide Dock	...		...		...		3	4380	0	468
West Entrance	60	0	7	9	35	9	...		...	
Northern West Lock Entrance	32	0	6	0	34	0	...		...	
Southern West Lock Entrance	20	0	6	0	34	0	...		...	
North Passage	20	0	3	0	30	0	...		...	
South Passage	80	0	7	9	35	9	...		...	
Canada Dock	...		...		...		17	4043	0	1272
South Passages .....East	50	0	6	6	35	6	...		...	
West	80	0	6	6	35	6	...		...	
Canada Lock	100	0	7	9	35	9	1	3479	0	487
Huskisson Dock	...		...		...		14	3451	0	1039
Huskisson Branch Dock	...		...		...		7	592	0	910
Huskisson East Lock	80	0	6	6	44	6	0	4682	0	342
Huskisson West Lock	45	0	6	0	32	0	0	3650	0	330
Sandon Dock, West Entrance	70	0	6	6	37	5	10	100	0	867
Wellington Half-tide Dock East Entrance	70	0	6	9	37	6	3	813	0	400
West Entrance	50	0	6	6	34	6	...		...	
Wellington Dock, West Pas.	70	0	6	6	37	6	7	4120	0	820
Bramley-Moore Dock, North Passage	60	0	6	0	32	0	9	3106	0	935
South Passage	60	0	6	0	32	0	...		...	

LIVERPOOL DOCKS—*continued.*	Width of Entrance.	Sill under Old Dock Datum.	Coping at Hollow Quoins above Sill.	Water Area.	Quay Space.
	ft. in.	ft. in.	ft. in.	Acr. Yd.	Mile Yd.
Nelson Dock...South Passage	60 0	6 6	32 6	7 4786	0 803
Stanley Dock...West Passage	51 0	5 8	34 8	7 120	0 753
Collingwood Dock, West Pas.	60 0	6 9	32 9	5 244	0 553
Salisbury Dock	...	...	...	3 2146	0 406
West Entrances ...North	60 0	6 11	32 11	...	...
South	50 0	6 11	32 11	...	...
Canal Lock	18 0	5 2	31 2	...	...
Clarence Graving Dock Basin North Passage............	45 0	4 9	30 9	1 1056	0 291
South Passage	45 0	4 6	31 0	...	...
Clarence Half-tide Dock West Entrance	50 0	5 6	34 0	4 1794	0 635
Clarence Dock, West Passage	47 0	3 2	29 2	6 273	0 914
Trafalgar Lock, North and South Passages	45 0	6 7	30 5	0 2937	0 256
Trafalgar Dock, South Passage	45 0	4 11	31 4	5 4546	0 764
Victoria Dock, South Passage	40 0	4 11	31 3	5 3559	0 755
Waterloo Dock	...	...	...	5 3056	0 737
Waterloo Lock ...North Pas.	45 0	6 5	33 0	0 2937	0 256
South Entrance	45 0	6 8	33 3	...	...
Prince's Dock and Locks, North Entrance	45 0	5 11	34 1	11 3889	0 1613
South Entrance	44 11	5 11	34 1	...	...
George's Dock and Passage, North Entrance	41 11	4 6	29 0	5 2593	0 1001
South Passage	40 1	4 6	28 11	...	...
		Sill above Old Dock Datum.			
Manchester Dock, West Ent.	32 10	0 3	23 0	1 595	0 339
		Sill under Old Dock Datum.			
Manchester Lock, West Ent.	33 8	3 9	28 0	0 315	0 57
Canning Dock, West Passage	45 0	6 1	32 3	4 376	0 585
Canning Half-tide Basin......	...	...	...	2 2688	0 429
Two West Entrances, each	45 0	6 3	34 6	...	...
Albert Dock...North Passage	45 0	6 4	32 4	7 3542	0 885
East Passage	45 0	6 0	32 0	...	...
Salthouse Dock ...North Pas.	45 0	6 0	32 0	6 2019	0 784
Wapping Basin ...West Pas.	40 0	6 0	31 0	1 3151	0 454
North and South Pas. each	50 0	6 0	32 0	...	...
Wapping Dock......West Pas.	50 0	6 0	32 0	5 499	0 815
South Passage	50 0	6 0	32 0	...	...
King's Dock ...South Passage	42 0	5 0	31 1	7 3896	0 875
Basin to Queen's Dock.........	...	...	...	3 3542	0 445
West Entrances ...North	70 0	6 9	37 9	...	...
South	50 0	6 9	37 9	...	...
Queen's Dock ......West Pas.	50 0	6 0	32 0	10 1564	0 1214
South Passage	60 0	6 6	35 3	...	...
Coburg Dock, West Entrance	70 1	6 0	32 3	8 26	0 1053
Brunswick Dock, North Pas.	60 0	6 6	33 6	12 3010	0 1086
Brunswick Half-tide Dock, East Passage	42 0	5 6	31 6	1 3388	0 491
West Entrance	45 0	6 0	32 6	...	...
Toxteth Dock, West Entrance	40 0	5 0	31 0	1 469	0 393
Harrington Dock, West Ent.	29 9	1 2	24 3	0 3740	0 315
Total Water Area and Quay Space of the Liverpool Docks				228 630	16 923

LIVERPOOL BASINS.	Width of Entrance.	Height of Piers above Old Dock Sill.	Coping at Hollow Quoins above Sill.	Water Area.	Quay Space.
	ft. in.	ft. in.		Acr. Yd.	Mile Yd.
Canada Basin......................	250 0	32 0	...	6 4528	0 546
Sandon Basin......................	200 0	31 0	...	6 904	0 702
Prince's Basin	156 0	27 10	...	4 1549	0 509
Seacombe Basin..................	52 0	21 10	...	0 1805	0 188
George's Basin	147 0	25 0	...	3 1852	0 455
George's Ferry Basin	70 0	23 8	...	0 1344	0 160
Manchester Basin	36 0	22 2	...	0 2568	0 288
South Ferry Basin	60 0	30 6	...	0 2927	0 205
Harrington Basin...............	40 0	23 3	...	0 3917	0 308
Total Water Area and Quay Space of the Liverpool Basins				23 2034	1 1600
Ditto ditto ditto Docks				228 630	16 923
Total				251 2664	18 763

BIRKENHEAD DOCKS.	Width of Entrance.	Sill under Old Dock Datum.	Coping at Hollow Quoins above Sill.	Water Area.	Quay Space.
	ft. in.	ft. in.	ft. in.	Acr. Yd.	Mile Yd.
Wallasey Pool, Western Float	...	...	...	52 319	2 210
Ditto ....Eastern ditto	...	...	...	59 3786	1 1506
Ditto ....Passage	100 0	7 6	34 0	...	...
Ditto, Basin near Canada Works, West	50 0	...	...	1 2554	0 543
Ditto, ditto ....East	50 0	...	...	1 84	0 390
Ditto, Railway Co.'s Basin	...	...	...	0 606	0 113
East Entrances to East Float					
From Egerton Dock............	70 0	7 0	32 0	...	...
„ Lock of Low Water Basin	50 0	...	...	0 1333	0 234
Inner Sill of Lock......	...	9 0	35 0	...	...
Outer Sill of ditto......	...	12 0	38 0	...	...
Two Sluicing Pas., each	30 0	...	...	...	...
Inner Sills of ditto ...	...	7 8	33 8	...	...
Outer Sills of ditto ...	...	18 6	44 6	...	...
From South Lock of Intermediate Dock	50 0	...	...	0 1522	0 300
Inner Sill of Lock ...	...	9 0	35 0	...	...
Outer Sill of ditto ...	...	12 0	38 0	...	...
From Middle Lock of Intermediate Dock	30 0	...	...	0 667	0 264
Inner Sill of ditto......	...	9 0	35 0	...	...
Outer Sill of ditto......	...	12 0	38 0	...	...
From North Passage of Intermediate Dock	100 0	9 0	35 0	...	0 242
Egerton Dock.....................	...	...	...	3 4011	0 754
Morpeth Dock, West Passage	70 0	5 3	30 3	11 522	0 1299
East Entrance	50 0	5 0	30 0	...	...
Morpeth Lock	85 0	12 0	38 0	0 3777	0 441
Intermediate Dock	...	...	...	8 2922	0 482
South Lock of ditto......	50 0	12 0	38 0	0 2222	0 391
Middle Lock of ditto ...	30 0	12 0	38 0	0 667	0 377
North Lock of ditto......	100 0	12 0	38 0	0 3888	0 352
Total Water Area and Quay Space of the Birkenhead Docks				140 4680	7 858

BIRKENHEAD BASINS.	Width of Entrance.	Height of Piers above Old Dock Sill.		Water Area.	Quay Space.
	ft. in.	ft. in.		Acr. Yd.	Mile Yd.
Part of Woodside Ferry Basin	160 0	24 0	...	0 3067	0 192
Morpeth Basin	300 0	25 6	S. side	7 2954	0 752
Ditto ditto	...	31 0	N. side	...	...
Low Water Basin	300 0	26 0	...	14 0	0 1360
North Basin	500 0	31 0	...	4 2406	0 556
Total Water Area and Quay Space of the Birkenhead Basins				26 3587	1 1100
Ditto ditto ditto Docks				140 4680	7 858
Total				167 3427	9 198

TOTAL WATER AREA AND QUAY SPACE OF THE LIVERPOOL AND BIRKENHEAD DOCKS AND BASINS.	Water Area.		Quay Space	
	Acrs.	Yds.	Mile	Yd.
Total Water Area and Quay Space of the Liverpool Docks and Basins	251	2664	18	763
Total Water Area and Quay Space of the Birkenhead Docks and Basins	167	3427	9	198
Total	419	1251	27	961

LIVERPOOL GRAVING DOCKS.	Width of Entrance.	Sill under Old Dock Datum.	Coping at Hollow Quoins above Sill.	Length at Bottom.	Total Length at Bottom.
	ft. in.	ft. in.	ft. in.	Lineal yd.	Lineal yd.
Canada Lock & Graving Dock	100 0	7 9	35 9	...	167
Huskisson Lock & Graving do.	80 0	6 6	41 6	...	132
Sandon Graving Docks .... No. 1, East	60 0	3 6	29 6	180	
No. 2 „	70 0	3 6	29 6	180	
No. 3 „	60 0	3 6	29 6	180	
No. 4 „	70 0	3 6	29 6	180	
No. 5 „	45 0	3 6	29 6	180	
No. 6 West	45 0	3 6	29 6	180	
					1080
Clarence Graving Docks—					
No. 1—Outer Gates ...	45 0	3 0	29 6	135	
No. 1—Inner Gates ...	45 0	0 6	18 6	97	
No. 2—Outer Gates ...	45 0	3 0	29 6	138	
No. 2—Inner Gates ...	32 10	0 6	18 6	96	
					466
		Sill above Old Dock Datum			
Canning Graving Docks, No. 1	35 9	1 $8\frac{1}{2}$	21 $6\frac{1}{2}$	147	
		Sill under Old Dock Datum.			
No. 2	35 9	0 $0\frac{1}{2}$	23 4	160	
					307
Queen's Graving Docks, No. 1	42 0	1 $8\frac{1}{4}$	29 4	146	
No. 2	70 1	3 6	30 11	145	
					291
Brunswick Graving do., No. 1	42 0	2 6	29 0	133	
No. 2	42 0	2 6	29 0	133	
					266
Total measure at the Bottom					2709

LEVELS OF THE TIDES OBSERVED AT LIVERPOOL.	Datum. Above.	Datum. Under.
	ft. in.	ft. in.
Average High Watermark of Spring Tides in 1816, 1819, 1820, and 1821	18 3	...
Ditto next ditto, or Equinoctial Spring Tide	20 0	...
Ditto next ditto, or ditto	22 0	...
An extraordinary Equinoctial Spring Tide, April, 1821	23 0	...
An extraordinary ditto, as marked on Leasowe Lighthouse..	25 0	...
Average High Watermark of Neap Tides in 1816, 1819, 1820, and 1821	11 3	...
Highest ditto	14 0	...
Lowest ditto	9 3	...
Average Low Watermark of Spring Tides in 1816, 1819, 1820, and 1821	...	8 9
Highest ditto	...	6 6
Lowest ditto	...	11 0
Average Low Watermark of Neap Tides in 1816, 1819, 1820, and 1821	...	1 9
Highest ditto	1 0	...
Lowest ditto	...	4 6
Mean Tide Level	4 9	...

BIRKENHEAD GRAVING DOCKS.	Width of Entrance.	Sill under Old Dock Datum.	Coping at Hollow Quoins above Sill.	Length of Bottom.	Total Length of Bottom.
	ft. in.	ft. in.	ft. in.	Lineal yd.	Lineal yd.
No. 1, Western Float	...	...	...	...	
No. 2, ditto	50 0	7 9	32 9	250	
No. 3, ditto	85 0	7 9	32 9	250	500
Morpeth Lock & Graving Dock	85 0	12 0	38 0		156
Total measure at Bottom					656
Ditto of the Liverpool Graving Docks					2709
Total					3365

GRIDIRONS.	Breadth.	Length.
LIVERPOOL.	ft. in.	ft. in.
Clarence Graving Dock Basin—		
Blocks South End 2ft. 2in. below Old Dock Sill / Do. North End 0 3 ditto ditto	25 6	313 6
Prince's Basin, North Side—		
Do. East End 2 8 above ditto / Do. West End 2 7 below ditto	26 4	273 0
Prince's Basin, South Side—		
Do. East End 2 1 above ditto / Do. West End 4 3 below ditto	25 0	235 0
King's Pier, Blocks level of Old Dock Sill	26 0	302 0
Total Length of Liverpool Gridirons	...	1123 6
BIRKENHEAD.		
Morpeth Basin, Blocks South End 1ft. 8in. above O.D.S....	36 3	228 3
Do, do. North End 1 $1\frac{1}{2}$ below ditto ...	...	...
Total Length of Gridirons at Liverpool and Birkenhead ...	...	1351 9

LIVERPOOL CORPORATION DOCKS.	Width of Entrance.	Level of Sill. Above Datum.	Level of Sill. Below Datum.	Level of Coping above Sill.	Water Area.
	ft. in.	ft. in.	ft. in.	ft. in.	Acr. Yd.
River Craft Dock, Lock, and Eagle Basin	...	...	...	...	
Outer Gates	30 0	0 3	...	25 1	1 3416
Inner Gates	30 0	1 3	...	24 7	
Duke of Bridgewater's Dock—					
Outer Gates	40 0	....	4 6	30 0	
Middle Gates	28 10	0 6	...	22 3	2 1336
Inner Gates	40 0	...	6 0	31 0	

(To be continued.)

ECONOMY IN THE USE OF STEAM.

By D. M. GREENE, C.E., Second Assist. Eng. U.S.N.

(From the Journal of the Franklin Institute.)

The special attention which has been recently attracted to this important subject, and the interest in it, which has been developed in popular no less than in professional minds, together with the wholly unsatisfactory and unprofitable popular discussions in relation to it, have induced the writer to undertake a reconciliation of the results of experiment with those of theory.

The experimental results alluded to, are the conclusions arrived at in the case of the experiments made some years since, at Erie, Pa., under the auspices of the United States Government, for the purpose of ascertaining the relative costs of net power, when steam is used with different measures of expansion; conclusions which are generally assumed to be entirely at variance with the theory hitherto almost universally accepted as true.

In the discussion which is to follow, the law of Mariotte is accepted as practically governing the case; except so far as it is necessarily modified by the comparatively recent discovery, that when heat is employed as a motive force, or "mode of motion," the work done is due to the transmutation of a definite amount of heat into work. According to the theory based upon the discovery alluded to, and which is now generally accepted by competent authorities everywhere, as correct, whenever an amount of work, equivalent to 772 pounds raised 1ft., is accomplished through the agency of heat, an amount of heat sufficient to raise 1 pound of water 1° Fahr. is transmuted into that work; in other words, the mechanical equivalent of a unit of heat* is 772 pounds raised 1ft. high; or it is equal to a force of 772 pounds exerted over a space of 1 linear foot.

Hence for each horse power developed by a steam engine, there are $\frac{33000}{772} = 42{\cdot}746$ units of heat transmuted into power; and as a necessary consequence, such transmutation must be attended by a certain, definite, condensation in the cylinder; whence we are forced to the conclusion, that the volume of steam which enters the cylinder during each stroke must be greater than the space displaced by the piston, by the volume condensed to produce the power developed.

As a simple example, showing the extent of condensation due to the production of power in a particular case, take a cylinder whose piston has an area of 3,300 square inches, 10ft. stroke, and makes 25 single strokes per minute; using a steam pressure of two atmospheres, or 29·4 pounds above zero. Then the total power developed will be—

$$\frac{3300 \times 29{\cdot}4 \times 10 \times 25}{33000} = 735 \text{ horses;}$$

and the heat transmuted into power, $735 \times 42{\cdot}746 = 31418$ units.

Now the total heat of steam of two atmospheres is 1190°; and its sensible temperature 250°: hence

$$\frac{31418}{1190 - 250} = 33{\cdot}4 \text{ pounds,}$$

or

$$\frac{33{\cdot}4 \times 841}{62{\cdot}5} = 449 \text{ cubic feet}$$

of steam will be condensed per minute. During the same time, the space displaced by the piston will be 5729 cubic feet, and the total volume of steam used, $5729 + 449 = 6178$ cubic feet; of which

$$\frac{449 \times 100}{6178} = 7{\cdot}26 \text{ per cent.}$$

is condensed to produce the power.

In the preceding example, we have supposed the steam to follow full stroke; when high measures of expansion are employed, the condensation —being proportional to the work done—will, of course, be largely increased; as, for example, when steam is expanded four times, the condensation will be

$$2{\cdot}38\left(\frac{449 \times 100}{5729}\right) = 18{\cdot}66 \text{ per cent.}$$

of the space displacement of the piston; so that, in order to realise the 2·38 units of work usually shown by theory to have been performed, the volume of steam admitted to the cylinder to do the work, and to preserve the tension must be

$$\frac{100 \times 100}{81{\cdot}34} = 123 \text{ units,}$$

instead of a single unit. It follows, therefore, that the gain in work, instead of being 138 per cent. of that realised when steam is used without expansion, is only

$$\frac{(238 - 123)\,100}{123} = 93{\cdot}5 \text{ per cent.}$$

We might easily modify this gain by the loss due to clearance, and by the constant prejudicial resistances of back pressure, and the friction of the engine itself; but we prefer to consider the general case, and deduce a formula which will give the cost of a net horse-power in pounds of water evaporated per hour, under any and every variety of practical conditions, as regards pressure, expansion, clearance, back and friction pressures; enough, however, has been said to awaken a suspicion in the intelligent mind, that the extravagant gains promised by theory—as applied and heretofore generally relied upon—are but myths.

In order to best accomplish our purpose, it is necessary, in the first place, to calculate the

MECHANICAL EFFECT AVAILABLE FROM THE EVAPORATION OF 1 POUND OF WATER PER HOUR, THE STEAM BEING USED WITHOUT EXPANSION.

FIG. 1.

Let A B, Fig. 1, be a tube of indefinite length, having a sectional area equal to 1 square inch; suppose it to contain a column of water one foot high; upon this water let a piston rest without weight, and capable of motion without friction. Then, when this filament of water has been converted into steam, under the pressure of the atmosphere, the piston will have been raised through a height D C = x; and an amount of work—

$$W = 14{\cdot}7\,x,$$

will have been done; in which x will represent the specific volume of steam of one atmosphere, less the condensation due to the production of the work + 1. To find the height of the tube due to the condensation, or the portion of the length of the tube which would have been occupied by the steam condensed, had no condensation occurred, we have $\frac{14{\cdot}7\,x}{772}$ = the number of pounds of water raised 1° by the heat transmuted into work; or putting T for the total heat, and t for the sensible temperature of the steam, $\frac{14{\cdot}7\,x}{772\,(T - t)}$ = the number of pounds of water which would be converted into steam from, and at a temperature t, by, the same heat. If, now, w represent the weight of a filament of water 1ft. high in the tube, we shall have, for the space occupied by the above weight of steam, in the state of water, $\frac{14{\cdot}7\,x}{772\,(T - t)\,w}$ cubic feet. If V represent the specific volume of the steam, then will the above volume of water, as steam, occupy $\frac{14{\cdot}7\,V\,x}{772\,(T - t)\,w}$ feet of the length of the tube; whence,

$$x = (V - 1) - \frac{14{\cdot}7\,V\,x}{772\,(T - t)\,w}.$$

or

$$x\left(1 + \frac{14{\cdot}7\,V}{772\,(T - t)\,w}\right) = V - 1.$$

$$\therefore\ x = \frac{V - 1}{1 + \dfrac{14{\cdot}7\,V}{772\,(T - t)\,w}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

* By "unit of heat," is of course meant an amount of heat sufficient to raise 1lb. of water 1° Fahr.

To find V, let V_1 be the specific volume of steam, as compared with the original water at the temperature of 62° Fahr., and P represent the tension of the steam (above zero) in inches of mercury. Then, according to Fairbairn's empirical formula,

$$V_1 = 25{\cdot}62 + \frac{49513}{P + {\cdot}72}.$$

Making $P = 30$, we get $V_1 = 1{,}637$; but we are seeking the specific volume of the steam as compared with the original water at the boiling point—212° in this case. To determine this we make use of the relations that the specific volumes of the steam are inversely proportional to the volumes of a given weight of water at the two temperatures mentioned, thus: $V : V_1 :: 1 : 1{\cdot}0365$.*

whence
$$V = \frac{V_1}{1{\cdot}0365} = \frac{1637}{1{\cdot}0365} = 1579.$$

Also at 212°, $w = {\cdot}42$ of a pound; $T = 1178{\cdot}6°$; $t = 212°$.
Substituting these values in (1) we get

$$x = \frac{1579 - 1}{1 + \frac{14{\cdot}7 \times 1579}{772\,(1178{\cdot}6 - 212)\,{\cdot}42}}$$

$$= 1169{\cdot}3 \text{ feet.}$$

Hence the work done by ·42 of a pound of water, when converted into steam of one atmosphere = $14{\cdot}7 \times 1469{\cdot}3 = 21598{\cdot}71$lbs. ft.; consequently for the work done by a pound of water under the same circumstances, if evaporated in an hour and reduced to horse power, we have

$$H\,P = \frac{21598{\cdot}71}{33000 \times 60 \times {\cdot}42},$$

$$= {\cdot}026 \quad \text{.......................................} \quad (2)$$

When steam is made under a pressure of 9 atmospheres, or $9 \times 14{\cdot}7 = 132{\cdot}3$lbs. per square inch, the work of a pound of water is found to be ·029 of a horse-power; but in securing the gain thus indicated, an additional expenditure of heat is required; so that when the proper reduction is made, we get ·0281 as the work accomplished by the same expenditure of heat or fuel that was required to develop the ·026 of a horse-power of (2). Now, assuming that the increments of work between one and nine atmospheres are equal—which, though not strictly true, is sufficiently near the truth for practical purposes—we get the following values. W being the work of 1lb. of steam per hour reduced to the standard of steam of one atmosphere.

Pressure in Atmospheres.	W.†	Remarks.
1	·026	Calculated.
2	·0261	Estimated.
3	·0263	"
4	·0266	"
5	·0269	"
6	·0272	"
7	·0275	"
8	·0279	"
9	·0281	Calculated.

In any case, to find the number of pounds of water required to be evaporated per horse-power (total), when the steam is used without expansion, and in a cylinder without clearance, it is only necessary to take the reciprocal of W, thus:—

$$\text{cost} = \frac{1}{W} \quad \text{.......................................} \quad (3)$$

If $W = {\cdot}026$, cost $= \frac{1}{{\cdot}026} = 38{\cdot}446$ pounds.

* The volumes of a given weight of water, at 62° and 212°, are to each other as 1 : 10365, very nearly.

† The numbers in this column, although strictly correct for the work of equal quantities of fuel only, may also be taken as representing the work of a pound of water, in each case, without appreciable error. The object here aimed at is more particularly to afford a means of comparison of the work done by equal weights of fuel.

We next pass to an estimate of the

EFFECT OF CLEARANCE.

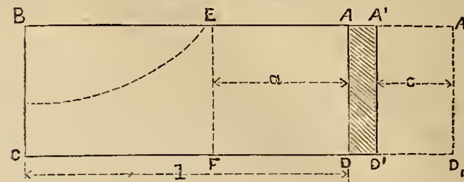


FIG. 2.

In Fig 2, let

l = length of stroke = C D.
a = space traversed by the piston before the steam is cut off.
c = clearance = $D_1 D^1$ = altitude of a cylinder whose diameter equals that of the cylinder, and whose volume equals the clearance space.
1 = unity = initial pressure of the steam above zero.
p_1 = mean pressure when the work per stroke is calculated independently of the clearance.
p_2 = mean pressure when the clearance is considered.

Then,

1. Neglecting the clearance, and calling the work done before the steam is cut off, unity, the work done during expansion will be represented by hyp. log. $\frac{l}{a}$; and the whole work per stroke,

$$1 + \text{hyp. log. } \frac{l}{a}.$$

Dividing this result by the ratio of l to a, we get

$$p_1 = \frac{a}{l}\left[1 + \text{hyp. log. } \frac{l}{a}\right] \quad \text{..........................} \quad (4)$$

2. Considering the clearance as a part of the stroke, and calling the work done before the steam is cut off, unity, as before—but a different unit—we have for the work done during expansion in terms of this last unit,

$$\text{hyp. log. } \frac{l + c}{a + c}:$$

or, since the last unit is $\frac{a + c}{a}$ times as large as the first, this work, compared with the first, will be

$$\frac{a + c}{a} \text{ hyp. log. } \frac{l + c}{a + c};$$

and, consequently, the work actually done by the steam during the entire stroke, in terms of the first unit, will be

$$1 + \frac{a + c}{c} \text{ hyp. log. } \frac{l + c}{a + c};$$

Dividing this by the ratio of l to a, as before, we get

$$p_2 = \frac{a}{l}\left[1 + \frac{a + c}{a}, \text{ hyp. log. } \frac{l + c}{a + c}\right] \quad \text{................} \quad (5)$$

It is clear that there has been a *loss in steam*, due to the clearance space, while, at the same time, there has been a *gain in work*, due to the expansion of the clearance steam; but the loss is greater than the gain, hence an absolute loss equal to their difference.

The loss in steam, compared with the cylinder steam, is $\frac{c}{a}$ while the gain in work, compared with the work done before cutting off is $\frac{p_2 - p_1}{p_1}$.

The steam and work in the first case being respectively equal to unity, and in the second case to $1 + \frac{c}{a}$, and $1 + \frac{p_2 - p_1}{p_1}$, respectively; and assuming that the work done under any given conditions should be proportional to the steam used, we have for the absolute loss of steam, or work,

$$\left(1 + \frac{c}{a}\right) - \left(1 + \frac{p_2 - p_1}{p_1}\right),$$

$$= \frac{c}{a} - \frac{p_2 - p_1}{p_1};$$

and for the loss in terms of, or compared with, the steam used in the second case,

$$\frac{\dfrac{c}{a} - \dfrac{p_2 - p_1}{p_1}}{1 + \dfrac{c}{a}}.$$

$$\therefore \text{ Loss} = \frac{c - \dfrac{a\,(p_2 - p_1)}{p_1}}{a + c} \quad \ldots\ldots\ldots\ldots \quad (6)$$

If now we substitute in (6) for p_2 and p_1 their values in (4) and (5), we obtain, first,

$$\frac{p_2 - p_1}{p_1} = \frac{\dfrac{a}{l}\left(1 + \dfrac{a+c}{a}\cdot \text{hyp. log. } \dfrac{l+c}{a+c}\right) - \dfrac{a}{l}\left(1 + \text{hyp. log. } \dfrac{l}{a}\right)}{\dfrac{a}{l}\left(1 + \text{hyp. log. } \dfrac{l}{a}\right)}$$

$$= \frac{\dfrac{a+c}{a}\ \text{hyp. log. } \dfrac{l+c}{a+c} - \text{hyp. log. } \dfrac{l}{a}}{1 + \text{hyp. log. } \dfrac{l}{a}}$$

which in (6) gives, for the clearance, an absolute

$$\text{Loss} = \frac{c - \dfrac{a\left[\dfrac{a+c}{a}\ \text{hyp. log. } \dfrac{l+c}{a+c} - \text{hyp. log. } \dfrac{l}{a}\right]}{1 + \text{hyp. log. } \dfrac{l}{a}}}{a + c}$$

$$= \frac{c}{a+c} - \frac{\left[\text{hyp. log. } \dfrac{l+c}{a+c} - \dfrac{a\ .\ \text{hyp. log. } \dfrac{l}{a}}{a+c}\right]}{1 + \text{hyp. log. } \dfrac{l}{a}}. \quad \ldots\ldots\ldots\ldots \quad (7)$$

By this formula the following table has been constructed, showing the losses due to clearance under the ordinary conditions of practice:—

Cut-off.	Per Cent. of Loss due to Clearance.			
	Clearance, 5 per cent.	Clearance, 6 per cent.	Clearance, 7 per cent.	Clearance, 8 per cent.
1-10th	20·90	23·65	26·48	28·93
2-10ths	13·60	16·68	18·73	20·90
3-10ths	11·25	13·19	15·03	16·18
4-10ths	9·40	11·01	12·60	14·18
5-10ths	8·09	9·57	10·98	12·21
6-10ths	7·20	8·47	9·76	10·97
7-10ths	6·47	7·59	8·79	9·84
8-10ths	5·79	6·84	7·85	8·98
9-10ths	5·21	6·23	7·19	8·16
10-10ths	4·76	5·66	6·54	7·69

Example.—Suppose it is found that, for a certain measure of expansion, without clearance, 35lbs. of steam will be required per horse-power per hour. Required the actual cost of a horse-power when the clearance is 8 per cent., and the steam cut off at 2-10ths.

We have,

$$\text{Cost} = \frac{35 \times 100}{100 - 20{\cdot}90} = 44{\cdot}25 \text{ pounds}:$$

Hence the absolute waste in this case will be 44·25 − 35 = 9·25lbs. of steam per horse-power per hour.

This reduction in the efficiency of steam, it will be observed, is in addition to the reduction due to condensation: taken together they probably amount to 40 per cent. of all the steam used. The exact amount, however, is at present unimportant, the immediate design being simply to direct the reader's attention to the progress being made in clearing away the mists which have so long obscured this subject.

It will be observed that if 40 per cent. of the steam is lost, or rather if only 60 per cent. of it is utilised, we shall realise from a unit of steam only 2·609 × ·6 = 1·565 units of work; that is, instead of realizing a gain of 1·609, we shall get only ·565, or about *one-third* the gain usually estimated for this measure of expansion.

(*To be continued.*)

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Bath Meeting, 1864.

ON SOME OF THE STRAINS OF SHIPS.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

In previous scientific investigations respecting the strains which ships have to bear, it has been usual to suppose the ship balanced on a point of rock, or supported at the ends on two rocks. The strains which would thus be produced are far more severe than any which have to be borne by a ship afloat. The author computes the most severe straining action which can act on a ship afloat, viz., that which takes place when she is supported amidships on a wave-crest, and dry at the ends, and he finds that the bending action cannot exceed that due to the weight of the ship with a leverage of one-twentieth of her length; and that the racking action cannot exceed about sixteen-hundredths of her weight. Applying those results to two remarkably good examples of ships of 2,680 tons displacement, one of iron and the other of wood, described by Mr. John Vernon in a paper read to the Institution of Mechanical Engineers in 1863, he finds the following values of the greatest stress of different kinds exerted on the material of the ship:—

In the iron ship, tension	3·98 tons per square inch.	
" thrust	2·35	"
" racking stress	0·975	"

It follows that in the iron ship the factor of safety against bending is between 5 and 6, agreeing exactly with the best practice of engineers, and that there is a great surplus of strength against racking.

In the wooden ship, tension	0·375 tons per square inch.	
" thrust	0·293	"

Here the factor of safety is between 10 and 15, which is also agreeable to good practice in carpentry. As for the racking action, the iron diagonal braces required by Lloyd's rules would be sufficient to bear one-third of it only, leaving the rest to be borne by the friction and adhesion at the seams of the planking.

ON UNITS OF MEASURE.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

The principal steps of late recommended to scientific men and to the public generally for the improvement of systems of measures, especially in Britain, may be classed under three heads, viz.:—

First—The promotion of the use of decimal multiplication and division, as applied to units of measure.

Second—The diffusion of knowledge as to the relations between the present British measures and those of the French metrical system.

Third—The abandonment, in scientific writings, of the use of the present British units of measure, and the adoption of the French units instead of them.

The utility of the first and second of those steps cannot be disputed, and all legal obstacles to the extension of them to trade, as well as to science, have been removed by a recent enactment.

But to the third step it appears to me that there are grave grounds of objections, and that those grounds should be carefully considered by the Association, and especially by the Mechanical Section, whose functions form a connecting link between science and practice, and some of whose members have expended much labour, capital, and skill in promoting the application of decimal subdivision to existing British units of measure, and in constructing instruments adapted to that purpose.

Those grounds of objection are the following:—

1. The connection between science and practice is so intimate that the disuse in scientific writings of fundamental units of measure which are extensively used in trade is impossible; and in considering the expediency of maintaining or abandoning the use of any such units, the interests of science and trade cannot be separated.

2. Amongst one-fourth of the population of the whole earth the standards of length are multiples of the British Inch, as the following calculation shows:—

	Approximate Population.
British Empire	174,000,000
Russian Empire	64,000,000
States of North America	32,000,000
Total	270,000,000

To justify the abandonment of an unit of measure, of which the established use is so extensive, it would be necessary to prove some very great advantage to be attained by the use of the unit to be substituted for it.

3. But no such advantage has ever been proved, or even alleged. The facts and arguments which have hitherto been brought forward in discussions on systems of measures are confined to the advantages of decimal multiplication and division, which can be applied to any unit whatsoever, and whose application to British units has long been extensively practised, and is now sanctioned by law.

4. An advantage for scientific purposes was formerly supposed to be possessed by the mètre, as being one ten-millionth part of the distance from the pole to the equator. But now that it is known, first, that the distance from the pole to the equator is not the same on different meridians, but differs to the extent of about 1-4,000th part of itself; secondly, that the French standard mètre is not exactly 1-10,000,000th part of the quadrant of any meridian, but approximately 1-10,001,562nd part of the quadrant of the meridian passing through Paris; and, thirdly, that our knowledge of the dimensions and figure of the earth is still, and will probably for ever continue, in a progressive condition,—the supposed advantage is known not to exist. This conclusion is in harmony with the opinion of Bessel, that in the measurement of a length between two points on the surface

of the earth, there is no advantage at all in proving the relation of the measured distance to a quadrant of the meridian.

In connection with this branch of the subject it may be remarked, that no comparison of a unit of measure with any "natural standard" can ever be more than approximate; for the art of comparing two measuring instruments or artificial standards with each other is, and must always continue, in point of precision, to be in advance of the art of measuring the object used as a natural standard, which is necessarily affected by more causes of error. At present, for example, the lengths of two bars can be compared together to the accuracy of one 1,000,000th part, and that degree of precision has been attained in practice by mechanical engineers; whereas no dimension of the earth, not even the polar axis, is yet known with certainty to the accuracy of one 100,000th part of itself.

5. Another advantage in a scientific point of view was formerly supposed to be possessed by the metrical system, from the kilogramme being the exact weight of a cubic decimètre of pure water at its maximum density. But it is now known that this supposed exact relation between the standards of measure and of weight not only does not exist, but is in all probability unattainable to that degree of precision which would realise the supposed scientific advantage; for the art of comparing two artificial standards of length or of weight together is, and always must continue, in point of precision, to be in advance of the art of finding the exact weight of a given volume of a given substance, which is necessarily affected by more causes of error. At present, two lengths can be compared together to the accuracy of one 1,000,000th part, and two weights to the accuracy of one 1-10,000,000th part; but it is very doubtful whether the weight of a given volume of pure water is known to the accuracy of 1-10,000th part.

6. In conclusion, then, it appears that while the advantages of decimal multiplication and division as applied to units of measure are incontestable, the question between different units, such as the mètre and the inch, is one of convenience, in which the interests of science and of trade cannot be separated; and inasmuch as the British inch and multiples of the inch are already established and used for practical purposes in regions inhabited by one-fourth of mankind, their use ought not to be abandoned in scientific writings.

PHOTO-SCULPTURE.

By A. CLAUDET, F.R.S.

Section A.—19th Sept., 1864.

If in our time opinions are divided as to whether photography is finally to exercise a beneficial influence upon the fine arts, or the contrary, there is no question that its innumerable useful applications are a boon to the community.

After having been habituated to photography, we can scarcely suppose it possible to do without photography, as we might say of railways, or of the electric telegraph.

Photography may have been the enemy of all that was inferior in the arts of painting and engraving, but is that to be regretted?

Instead of the dabblers in portraiture who were satisfying a morbid taste, we have a great army of photographers capable of representing the human form and features in the utmost perfection. Printing itself, that universal and powerful aid of civilisation, was only established by superseding a class of artists who had, at least, the merit of spreading, by their work, knowledge and literature during many centuries. They indeed produced true works of art which, though no longer repeated, are to be admired in the museums where they are preserved.

As to the art of painting, instead of being injured, it is served by photography, which enables artists to be more perfect in their design, and to study the beauty of forms yielded by the photographic mirror.

Photography, in multiplying marvellous representations of the beauties of nature, tends to inculcate the taste for artistic productions. There will be fewer bad painters because there will be less and less demand for inferior paintings. Fine works only will be esteemed, and the taste for art will increase in proportion to the value of its productions.

Is it not the same in literature? Who can deny that the more it is refined and pure, the more it educates and disposes the mind to reject whatever has not the stamp of genius?

In an enlightened age, inferior literature cannot exist. So the fine arts will be improved by photography. Notwithstanding the alarm of narrow minds incapable of appreciating progress, the discoveries which are based upon science will ultimately produce good, and benefit society. To the painter, photography affords the means of being absolutely correct in design. Reference to photographs in painting portraits, representing draperies, &c., saves immense trouble, and obviates the necessity of long and repeated sittings.

But how can it be said that photography prevents the artist from imparting to his work the impress of genius? Photography is for him only a useful auxiliary.

Nothing, however, can arrest the strides of photography; it extends every day its applications and gradually invades every art.

Who would have expected that photography was to be the means of sculpture!

Yet, however extraordinary such a prognostication might appear, however difficult at first thought it may be to understand, the possible connection between flat representation of objects and their solid form, it has been proved that from flat photographs, a bust, a statue, or other object of three dimensions can be made by a mechanical process without the necessity of the sculptor's copying the original, or even seeing it at all. Yet the result is a perfect fac-simile of the original. Moreover, the work is executed in one-tenth of the time required for modelling by hand.

This beautiful application of photography is called photo-sculpture, and is the invention of M. Willème, an eminent French sculptor.

Before explaining how M. Willème was led to this discovery, let me remind you that photography itself was invented by painters of talents, by artists, who, while using the camera obscura for studying the subject of their intended pictures, were struck with the beauty of those natural representations. In contemplating them they naturally desired that the pictures could be permanently fixed. Considering that these pictures were formed by the light reflected from the objects, they essayed to fix them by availing themselves of the known scientific fact that light had the property of blackening certain chemical compounds.

The flash of that idea was enough; their genius and perseverance solved the problem, and they created that art which they desired so much—photography.

A similar, and no less instructive story, may be told of photo-sculpture. M. Willème was in the habit, whenever he could procure photographs of his sitters, of endeavouring to communicate to the model the correctness of those unerring types. But how should he raise the outlines of flat pictures into a solid form?

Yet these single photographs, such as they were, could serve him to measure exactly profile outlines. He could, indeed, by means of one of the points of a pantograph, follow the outline of the photograph, while, with the other point directed on the model, he ascertained and corrected any error which had been communicated to his work during the modelling. What he could do with one view, or one single photograph of the sitter, he might do also with several other views if he had them. This was sufficient to open the inquiry of an ingenious mind. He saw at once that if he had photographs of many other profiles of the sitter, taken at the same moment, by a number of camera-obscuras placed around, he might alternately and consecutively correct his model by comparing the profile outline of each photograph with the corresponding outline of the model. Such was the origin of a marvellous and splendid discovery. But it soon naturally occurred to him, that instead of correcting his model when nearly completed, he had better work at once with the pantograph upon the rough block of clay, and cut it out gradually all round in following one after the other the outline of each of the photographs.

Now supposing that he had 24 photographs, representing the sitter in as many points of view (all taken at once), he had but to turn the block of clay after every operation, $\frac{1}{24}$ of the base upon which it is fixed, and to cut out the next profile, until the block had completed its entire revolution, and then the clay was transformed into a perfect solid figure of the 24 photographs—the statue or bust was made.

When this is once explained every one must be struck with admiration at the excellence of the process. It is so sure and so simple, that we are surprised it had not been thought of before. But so it is with the most valuable inventions. They wait until some genius grasps the idea and conceives how to make them practical.

It will, perhaps, be argued as a defect of photo-sculpture, that, being the result of a mechanical process, it leaves no opportunity for the display of artistic taste or feeling, and that its productions must therefore be only vulgar and matter of fact. This would be a mistake; because the sculptor who has to direct the last operation, will exercise his skill in communicating to the model all the refinements with which, as a sculptor merely, he could have endowed it. For supposing the photographs to have been deficient in attitude or expression, in giving the last touches to the model, the sculptor can correct those imperfections. The pantograph of photo-sculpture will communicate to the clay the true character and the proportions of the object, with all the correctness of the photographs; it will produce a perfect likeness, and it will be necessary to give to this first draught the softness and finish of a work of art. These of course cannot be imparted except by the skilful hand and the intellectual feeling of a true artist. In short, as the model must be touched by a sculptor, it is clear that the sculptor so engaged should be such as will not spoil the work of the unerring machine; but on the contrary, improve it in many particulars, and even add to it the sentiment of art. Therefore the process of photo-sculpture is to put in the hands of a skilful sculptor a model perfect in its proportions, correct in design, full of character, including draperies of the most elegant outlines such as are only represented by photographs; and this model, so prepared for him, would have required a tedious labour with the disadvantage of much uncertainty.

As photography has been the means of improving the art of painting, so photo-sculpture is destined to improve sculpture, and to spread in all classes the taste for this noblest branch of the fine arts. It may be said that sculpture is understood only by a very limited number of educated minds. It is seen only in palaces, in the public galleries, and in the mansions of the rich. Good sculpture is very expensive, and for this reason it is not customary for the middle-classes to employ sculptors to execute busts or statuettes of relatives or friends. Besides the question of price, there are very few artists capable of producing such a work as shall be an inducement to the possession of this kind of similitude. Photo-sculpture therefore opens a new era by the advantages of its procedure. The work is done with greater accuracy, in a very short time, and consequently at a moderate price. The original has only to sit once for the photograph, and then in a few days, without further trouble, or the necessity of appearing repeatedly before the sculptor, a bust or statuette is produced. Such facilities cannot fail to make the demand very general, and this must cause the employment of a great number of artists. The "ateliers" of photo-sculpture are indeed to be the best school of sculpture, from which will issue a succession of skilful artists, who, having practised the mechanical process, will be able, when photographs cannot be obtained, to model by hand. Therefore the art of sculpture must in every way benefit from the practice of photo-sculpture, which undoubtedly we shall see honoured in the dwellings of thousands, not only as regards portraiture in general, but also as to the resemblances of those who by their genius and virtues have deserved our admiration and esteem.

Again, photo-sculpture will be the easy and inexpensive means of reproducing in various sizes, and with unerring faithfulness, the beautiful remains of antique sculpture, whether statues, vases, or other objects which can only be seen in museums and galleries, and thus the public can possess, at a small cost, copies, or rather fac-similes, of the great creations of past ages. The only copies existing of those works cannot often be repeated, for they must be made at some risk of injuring the original, the only process hitherto known being that of

taking casts; hence they are expensive and rare. To obtain a certain number of photographs of these precious relics is all that will be needed for their reproduction by the photo-sculpture process.

Photography has already been the means of copying the paintings of celebrated masters existing in public and private galleries. By those photographs everyone is enabled to possess copies of the noblest works in the art of painting These copies contain composition, design, and everything capable of conveying the feeling of the artist; but they are deficient in one essential—colour.

It is otherwise as regards the representation of statuary which leaves to the mind to imagine colour. Photo-sculpture has then the advantage of reproducing works in sculpture without depriving us of any of the attributes which have made them famous.

Photo-sculpture will further be applied to the representations of animals, showing them in true and natural attitudes; by this means faithful models will be introduced in the manufacture of porcelain, clocks, furniture, and much that contributes to the embellishment of our dwellings.

In a word, photo-sculpture is calculated to spread the taste for the beautiful in form; it opens a new era, which will be remarkable in the history of the fine arts.

I have thought that I could not give to the meeting a better illustration of the process of photo-sculpture than by executing the bust of our illustrious President, Sir Charles Lyell. I invited Sir Charles for this purpose, and he was kind enough to sit for his photographs on the 16th August.

The machine has done the work, the sculptor has given the finishing touch to the model, and here is the bust completed, Sir Charles not having seen it before I brought it to the meeting.

In so short a time I have also been able to obtain of the same bust a model in bronze, and I leave to the meeting to form some opinion of photo-sculpture by this and other examples now near me.

THE GOLD, SILVER, AND BRONZE COINAGE OF 1863.

It is an extraordinary fact that the annual return of work done at her Majesty's Mint seldom or never makes its appearance until seven-twelfths of a year after the date to which that return extends. One would suppose that most careful note is daily made in that important establishment of every piece of money struck therein, and that the casting up of the total number of coins issued between the 1st of January and the 31st of December in any one year might be accomplished in less than seven months, even without the aid of Mr. Babbage or his machine. We do not mean to assert that the public suffer by the delay, or that it is of serious moment to anybody but impatient members of the Statistical Society. It is, however, "unbusiness like," and it gives colour and form to the censures so frequently and freely passed upon Government establishments and the officials connected with them. Let us hope for better things next year. Mr. Peel, whose name appears upon the coinage return for 1863 which now lies before us at present, or his successor, may feel disposed, perhaps, after this notice, to "move earlier" in the coming season than the month of June for an account of the "monies of the realm" coined from the 1st of January to the 31st of December, 1864. The public of our day prefer the speed of the railway train to the "snail's gallop" of the road waggon; and those who move slowly must be driven. Let it not be imagined that we desire to cast imputations upon the authorities of the Mint, or to blame them for inactivity. On the contrary, the return of which we speak would justify a certain amount of praise being awarded them. The quantity of metal, precious and otherwise, converted into coin of various denominations at that establishment last year, is very large, as will be seen from the following abstract. The number of ounces of gold transformed into sovereigns and half-sovereigns was 1,696,939·01. These produced of sovereigns 5,921,669, and half-sovereigns 1,371,574. Of silver converted into florins we have 341,280·00 ounces yielding 938,520 pieces. Of silver afterwards issued in the form of shillings the quantity used at the Mint in 1863 was 156,240·00 ounces, producing 859,320 pieces of money. The number of sixpences struck from 44,640·00 ounces was 491,040, and the number of threepences from 43,404·00 ounces, 954,888. For the Queen's Maunday money 516 ounces were stamped in the form of silver fourpences, twopences, and pence into 16,830 coins.

Of Bronze 340 tons weight was used for the purposes of coinage, and this produced 28,062,720 pence, 15,948,800 halfpence, and 1,433,600 farthings. The total nominal value of this large amount of the subsidiary denominations of money was £151,648. In addition to the foregoing, something like 4,000,000 of silver and bronze coins were struck for circulation in the British colony of Hong Kong.

The total number of coins of all denominations produced during the past year by the Royal Mint was therefore 59,998,961; this gives an average of rather more than eleven hundred thousand five hundred coins per week, and is not far off 200,000 per day.

It cannot be said, therefore, that the men or the machinery of that place have been idle during the year 1863, and we only have to complain of the very tardy appearance of the return from which the above figures have been collated. It is neither just to the public nor to the money manufactory itself, that the doings of the Mint should so long remain concealed under the dark shadow of official apathy, or by the mysterious but potent influence of *red-tape*.

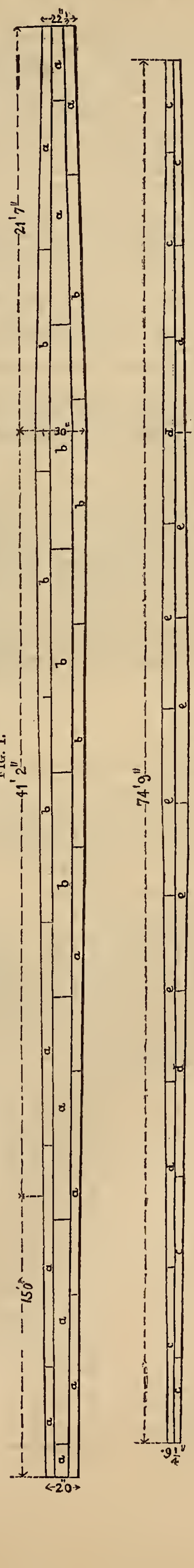


Fig. 1. Fig. 2.

$a = \frac{3}{8}$in.; b = 7-16ths in.; c = 3-16ths in.; $d = \frac{1}{4}$in.; e = 5-16ths in.

SCOTTISH SHIPBUILDERS' ASSOCIATION.

ON IRON AND STEEL SPARS.

By Mr. J. G. Lawrie.

The use of iron and steel spars in ships' seems to follow not unnaturally the use of iron ships. In the one as in the other, it is important that the material used should be free from defects, that it should be durable, and that it should be strong.

There has been, perhaps, no instance of innovation upon established custom in which casualties so unimportant have occurred as in the substitution of iron and steel spars for those of timber. Indeed, the writer is not aware of any instance in which accidents have happened owing to the spars being made of iron or steel, when the spars have been fairly used. If spars of iron and steel are used with standing rigging that will stretch, they are improperly used, and will give way in all probability, as has been known to occur when the rigging has been of hemp. When the rigging stretches, or becomes loose from change of weather, it may be that the spar, being of a kind which will not bend much without injury, is unsupported, and is not intended nor fitted to sustain the strain that is then thrown upon it.

Iron and steel spars have been made in several ways. They have been made plain tubes. They have also been made plain tubes with angle or T iron ribs rivetted longitudinally on the inside of the tube; and they have been made tubes with divisions and stays arranged and fashioned in sundry ways. On comparing these plans, it appears to the writer that the plain tube form of spar is the best. If the thickness of the material of the tube is such that the spar will retain its tubular form under strain; or, in other words, if the thickness is such that when the spar is subjected to heavy strain the plates which form the tube do not pucker—and in practice the thickness of the plates used is found to be sufficient for that purpose is plain that the strength of the spar is much more effectually increased by adding to the thickness of the plates forming the tube, rather than by putting angle or T iron, or stays or divisions of any kind, in the inside. By increasing the thickness of the plates, the material is concentrated in the position where it is most effectively applied to resist rupture, while, if material is introduced in the inside of the tube in the form of ribs, that material would be comparatively little strained until the material forming the tube would be fractured.

In considering the propriety of using iron and steel spars in substitution for those of timber, it is desirable to compare their strength; and for that purpose Figs. 1 and 2 represent the fore mast and lower yard of a ship of 1,000 tons register, and these spars are selected in illustration of the different descriptions of spars. The mast measures 77ft. 9in. long × 30in. at the partners, and the yard 74ft. 9in. long × 18½in. in the slings. The mast is of iron, and not steel, the thickness of the plates being $\frac{7}{16}$ths of an inch at the partners, tapered to $\frac{6}{16}$ths of an inch at the head and heel, having the longitudinal seams double rivetted, the butts of the $\frac{7}{16}$in. plates quadruple rivetted, and of the $\frac{6}{16}$in. plates triple rivetted, with butt straps $\frac{1}{16}$th of an inch thicker than the plates, by 18in. and 15in. wide respectively for the quadruple and triple rivetting. The yard is of steel, the thickness of the plates being $\frac{5}{16}$ths of an inch at the slings, tapered to $\frac{3}{16}$ths of an inch at the arms—having the longitudinal seams single rivetted, the butts of the $\frac{5}{16}$ths in. plates triple rivetted, and the remainder double rivetted, the plates overlapping at the butts.

The strength of a timber mast plainly depends most materially on the quality

of the timber, and its freeness from defects, whether apparent or latent. The strength of a built timber mast is not greater than that of a solid mast, except to the extent that it is freer of flaws, and made of perhaps sounder timber, because smaller. It must not be forgot, however, that the strength of a built timber mast is lessened by the bolts for fastening the logs together. Assuming that the timber of which the mast is made is such that a piece 12in. square and 12ft. long between the supports would carry safely 7 tons on the centre, the* strength of a timber mast is nearly as much as that of an iron mast, made, as above described, of iron which will carry safely in extension 8 tons to the square inch, the iron mast being one half per cent. stronger than the timber mast. Pitch pine selected ought to carry 7 tons on the centre of a beam 12in. square and 12ft. between the supports, when it is new; but it is impossible to know how many mast pieces are of that quality, nor how long they will continue to be so.

Assuming that the timber yard is made of this quality of timber, and that the steel yard is made, as above described, of steel which will carry safely in extension 13 tons to the square inch, the steel yard is nearly twice as strong as the timber yard†—the steel yard being stronger than the timber yard in the proportion of 19 to 10.‡

Another important inquiry in the comparison of iron and steel spars with those of timber is their relative weight.

The pitch pine solid mast§ weighs 6 tons 3 cwt. nearly; the built timber mast, 6 tons $13\frac{1}{2}$ cwt.; and the iron mast, 5 tons 5 cwt.

The pitch pine solid yard‖ weighs 1 ton 16 cwt.; the built timber yard, 1 ton $19\frac{1}{2}$ cwt.; and the steel yard, 1 ton 13 cwt.

In these calculations of weight, the pitch pine is taken at 46lbs. to the cube foot, which the writer believes is below the average weight of that timber, and the advantage of lightness is therefore even more in favour of iron and steel spars than appears from these statements.

Another matter for comparison is the durability of spars.

If iron masts are kept properly painted, there is scarcely a limit to their last. There is no difficulty in painting them externally, nor is it insuperable to repaint lower masts internally, either by an apparatus contrived for the purpose, or, as their diameter is considerable, by a painter being let down inside. With respect to all the other spars, whether of iron or steel, none of which are used, like the lower masts, as ventilators, they are easily painted externally from time to time; and if they are plugged air-tight, so as to exclude the action of the atmosphere, the original painting will continue good, and renewal will be rarely necessary.

When iron or steel spars are new, their soundness is known, as the quality and condition of the material is tolerably well ascertained in making the spars; and when the spars are not new, their condition and strength are easily examined.

The soundness of timber spars, on the other hand, is by no means so easily known or maintained. In the first instance, there is considerable uncertainty about the soundness of any spar piece, notwithstanding all the examination that can be made; and even if sound when new, the durability is in no case equal to that of a plate of iron or steel. There is, besides, a great difference in the last of different spar pieces, owing either to original quality or to decay arising from exposure to different climates; and the last of a pitch pine spar may be put at from five to fifteen years.

Thus it will be acknowledged that, while at any time the condition of iron or steel spars is easily ascertained, it is difficult to know with certainty the condition of any timber spar, especially after it has been in use for some time; and in sending a ship to sea with the one kind of spars or with the other, there is all the difference betwixt knowing precisely the fitness of the one, and knowing almost nothing about the fitness of the other—a difference that is most important to underwriters, and eventually to shipowners.

There is a fourth important element in the comparison of the spars—"the cost."

The price of iron, or steel, or timber spars plainly depends, to some extent, on the price of iron, steel, and timber, and these vary from time to time. In the calculations for this paper, which are given in detail in a note, the prices of these articles are taken as follows:—

Iron plates	at £13 per ton.
Steel plates	at 20 per ton.
Timber for solid masts and yards	at 6s. to 2s. 6d. per foot.
Timber for built masts and yards	at 4s. to 2s. 6d. per foot.

And with these prices the following are the results:—

Solid timber mast*	£184
Built timber mast	187
Iron mast	92
Solid timber yard	£71
Built timber yard	78
Steel yard	47

—showing a large advantage in the iron and steel spars. It is true that this advantage will be somewhat modified by the changes that occur in the price of material, but by an examination of the detail of the calculations it appears that

---

* The strength of the timber mast $= \dfrac{0{\cdot}7854 \times f \times r^3}{l}$.

For pitch pine of the quality described in the text .... $\Big\}\, f = 2{,}000$, r = radius of mast = 15 inches.

The strength of the iron mast $= \dfrac{0{\cdot}7854 \times f' \times r^3\,(1 - n^4)}{l}$.

r = radius of mast = 15″, $r\,(1-n)$ = thickness of material of mast $= \frac{7}{16}$ $f' = 18{,}000$.

$\therefore$ Strength of timber mast : strength of iron mast $:: fr^3 : f'\,r^3\,(1-n^4)$.
$:: 2{,}000 : 2{,}010{\cdot}6$.

† By the same process as with the mast, and putting for steel, $f' = 30{,}000$.
Strength of timber yard : strength of steel yard $:: f\,r^3 : f'\,r^3\,(1-n^4)$.
$:: 2{,}000 : 3{,}855$.

‡ In a collision which lately occurred on the Clyde, a yard was carried away with apparently less strain than the makers of the yard expected it would have resisted. It must be borne in mind, however, that spars of either iron or steel will not bend so much as those of timber, and they are therefore probably less fitted to withstand collision, inasmuch as the timber spar, in bending, answers partly the purpose of a buffer. It must not be forgot, either, that occasionally, with iron and steel spars as with those of timber, material of a reedy or otherwise defective character will escape all the examination that can be made. The calculations of this paper would, of course, be vitiated in the case of defective material, and are made on the assumption that, for iron, the material will carry in extension safely 8 tons per square inch of section, and for steel, 13 tons per sq. inch.

§ Weight of solid pitch pine mast—

	tons	cwt.	qrs.	lbs.
Contents of mast piece = 282 cub. ft., at 46lbs.	5	15	3	20
Contents of cheeks = 15 cub. ft., at 50lbs.	0	6	2	22
Bolts	0	0	1	10
	6	2	3	12
Add for hoops and additional bolts in built mast	0	10	2	18
	6	13	2	2
Weight of iron mast,—Plates	4	19	2	15
Cheeks	0	4	1	14
Rivets	0	5	0	0
Invoice weight of material used =	5	9	0	1

‖ Weight of solid pitch pine yard—

Contents of spar = 87·45 cub. ft., at 46lbs	1	15	3	18
Add for hoops and bolts in built yard	0	3	2	10
	1	19	2	0
Weight of steel yard,—Plates	1	12	2	10
Rivets	0	1	3	24
Invoice weight of material used =	1	14	2	6

* Cost of masts, 77′ 9″ long × 30″ at the partners:—

Solid Timber Mast—

	£	s.	d.
Timber of main piece, = 80′ 0″ × 2′ 8″ = 560 cub. ft., at 6s.	£168	0	0
Timber for checks ... ... = 30 cub. ft., at 5s.	7	10	0
Bolts for do. ... ... = 38 lbs. at 3d.	0	9	6
Sawing ... ... = 1833 sup. ft., at 2s. 9d.	2	9	6
Workmanship of carpenters	6	0	0
	£184	9	0

Built Timber Mast—

	£	s.	d.
Timber of main piece, = 8 logs, 44′ 0″ × $16\frac{1}{2}$″ = 664 cub. ft. at 4s.	£132	16	0
Timber for cheeks... ... ... = 30 cub. ft., at 5s.	7	10	0
(cwt. qr. lbs.)			
Bolts for do. ... ... = 5 0 0 at 2d.	4	13	4
Hoops ... = $4\frac{1}{2}$″ × $\frac{3}{8}$″, spaced at 3′ 0″ = 6 0 0 at 4d.	11	4	0
Sawing ... ... = 2,900 sup. ft. at 2s. 9d.	3	19	9
Workmanship of carpenters, = 6 men for 3 weeks ...	27	0	0
	£187	3	1

Iron Mast—

	£	s.	d.
(tons cwt. qr. lbs.)			
Weight of plates ... ... = 4 19 2 15 at 13s.	£64	15	3
Weight of cheeks ... ... = 0 4 1 14 at 13s.	2	16	10
Weight of rivets ... ... = 0 5 0 0 at 14s.	3	10	0
Workmanship—number of plates ... = 22 at 10s.	11	0	0
Workmanship—number of rivets ... = 1,600 at 6s. 6d.	5	4	0
Paring and caulking—number of yards = 92 at $6\frac{1}{2}$d.	2	9	10
Workmanship at checks	3	0	0
	£92	15	11

Solid Timber Yard—

	£	s.	d.
Timber ... 1 log = 80′ 0″ × 20″ = 224 cub. ft. at 6s.	£67	4	0
Sawing ... ... = 1,440 sup. ft. at 2s. 9d.	1	19	7
Workmanship	2	0	0
	£71	3	7

Built Timber Yard—

	£	s.	d.
Timber ... 2 logs = 46′ 0″ × 20″ = 253 cub. ft. at 4s.	£50	12	0
Hardwood to fish, 8 pieces = 45′ 0″ × 3″ × 7″ = 50′ 8″ at 5s.	12	13	4
Hoops ... = $3\frac{1}{4}$ × $\frac{1}{4}$, spaced at 4′ 0″, = 240lbs. at 4d.	4	0	0
Bolts ... ... 162lbs at 2d.	1	7	0
Sawing ... ... = 1,500 ... ... at 2s. 9d.	2	1	3
Do. ... ... = 600 ... ... at 4s.	1	4	0
Workmanship of carpenters	6	0	0
	£77	17	7

Steel Yard—

	£	s.	d.
(tons cwt. qr. lbs.)			
Weight of plates ... ... = 1 12 2 10 at 20s.	£32	11	9
Weight of rivets ... ... = 0 1 3 24 at 18s.	1	11	5
Workmanship—number of plates ... = 16 at 10s.	8	0	0
Rivetting—number of rivets ... 1,100 at 7s. 6d.	4	2	6
Paring and caulking ... ... = 60 yards at 5d.	1	5	0
	£47	10	8

the advantage will usually be not less in favour of the iron and steel spars than these figures indicate.

Thus in strength, weight, durability, and cost, it would appear that timber spars are much behind those of iron and steel.

In a ship of 1,000 tons, the difference of weight for lower masts and bowsprit of iron; top-masts, lower yards, double fore and main top-sail yards, and single mizzen top-sail yard, of steel, will be about 7 tons 15 cwt., and the difference of cost will be about £500, being a saving to the shipowner of 10s. per ton.

The use of iron and steel spars has been for some time gradually making way; but recently the scarcity and price of pitch pine has induced their more rapid introduction than would probably in other circumstances have taken place—a result arising from the American war—and there are grounds now to believe that for the future pitch pine, or any other kind of timber spars, will not again be in demand. No doubt some men will for a time prefer timber spars to those of iron and steel, just as occurred when timber ships and hemp cables were being supplanted by those of iron; but it appears to the writer that, without retarding the change much, these men will only perform the duty of mile posts, by marking its progress, and that there seems to be no doubt that the days of large or heavy timber spars are numbered.

In a note afterwards received from Mr. Duncan, enclosing the following table of the costs of iron masts and steel yards, he says that top-masts and small yards that can be got at ordinary price, say two shillings to four shillings, are invariably cheaper in wood than steel, and the smaller the greater difference. So that the advantage in cost to the shipowner of using steel down to small sizes is doubtful, ten shillings per ton, or anything, unless for durability; and I am perfectly satisfied that anything under 50ft. long, or 12in. diameter, or four shillings per foot, is cheaper and better of timber, setting the want of elasticity and thinness of steel plating, and difficulty of making, against the greater calculated strength of the steel spar.

The Cost of Iron Masts and Steel Yards.—By R. Duncan.

Iron Plates, £12 per Ton; Steel, £21 per Ton; Work, £8 and £9.

Feet Length	Inches diameter.	Plate in Thickness.	Tons weight.	Average per Sup. Foot of Plate.	Rate of per Ton.	Price of Mast Tube.		Weight of Mounting in cwts.	Rate.	Cost of Smithy Mounting.		Cost of Masts, &c., complete.	
				lbs.	£	£	s.		s.	£	s.	£	s.
100	36	$\frac{1}{2}$ & $\frac{7}{16}$	10·7	20	20	214	0	40	40	80	0	294	0
90	33	$\frac{1}{2}$ & $\frac{7}{16}$	8·0	19	20	160	0	32	40	64	0	224	0
80	30	$\frac{7}{16}$ & $\frac{3}{8}$	6·2	$17\frac{1}{2}$	20	122	0	25	40	50	0	172	0
75	$27\frac{1}{2}$	$\frac{7}{16}$ & $\frac{3}{8}$	4·11	16	20	97	0	19	40	38	0	135	0
70	25	$\frac{3}{8}$ & $\frac{3}{8}$	3·15	15	20	75	0	15	40	30	0	105	0
65	22	$\frac{3}{8}$ & $\frac{5}{16}$	3·0	14	20	60	0	12	40	24	0	84	0
60	20	$\frac{3}{8}$ & $\frac{5}{16}$	2·10	14	20	50	0	10	40	20	0	70	0
Steel Yards.													
100	25	$\frac{3}{8}$, $\frac{5}{16}$, & $\frac{1}{4}$	4·10	14	30	135	0	18	40	36	0	171	0
90	22	$\frac{5}{16}$, $\frac{1}{4}$, & $\frac{3}{16}$	3·11	13	30	106	10	14	40	28	0	134	10
80	20	$\frac{5}{16}$, $\frac{1}{4}$, & $\frac{3}{16}$	2·13	12	30	79	10	$10\frac{1}{4}$	40	20	10	100	0
75	$18\frac{1}{2}$	$\frac{5}{16}$, $\frac{1}{4}$, & $\frac{3}{16}$	2·3	11	30	64	10	$8\frac{1}{4}$	40	16	10	81	10
70	$17\frac{1}{2}$	$\frac{5}{16}$, $\frac{1}{4}$, & $\frac{3}{16}$	1·17	11	30	55	10	$7\frac{1}{2}$	40	15	0	70	10
65	16	$\frac{1}{4}$, $\frac{3}{16}$, & $\frac{1}{8}$	1·10	9	30	45	0	6	40	12	0	57	0
60	15	$\frac{1}{4}$, $\frac{3}{16}$, & $\frac{1}{8}$	1·4	$8\frac{1}{2}$	30	36	0	5	40	10	0	46	0

(Signed) R. Duncan.

The following is the copy of a communication received from Mr. Hamilton, and furnished at the suggestion of the chairman.

"Note of the experience of Messrs. Barclay, Curle, & Co., as to the cost of iron and steel masts and spars for a ship of 1,200 tons, and also, for comparison, the *actual* cost of three built masts, and an *estimate* of the cost of the other wood spars of similar size to the steel ones.

"None of these spars were made by piece-work. For the net finished weight a deduction of about 10 per cent. should be allowed for waste.

"The price of the wood spars is calculated at the current rates which obtained, with very slight variations, for many years before the American war.

"In making up the net cost of iron masts, we make no allowance for steam power, machines, coals, and tools—a considerable item in the manufacture of iron masts, and which item is added in the cost of the following:—

	T. cwt. qr. lb.	£ s. d.	Iron and Steel. £ s. d.	Wood. £ s. d.
Bowsprit, $35\frac{1}{2}$ft. over all × $221\frac{10}{12}$ft. cube.				
Iron, $\frac{3}{8}$ and $\frac{7}{16}$in thick.				
Plates	2 5 2 7	23 14 0		
Rivets	0 1 3 5	1 1 6		
Paints, oils, use of tools, &c.		2 0 2		
Wages		7 13 2		
	2 7 1 12		34 8 10	
14s. 7d. per cwt., or 3s. 1d. per cubic foot.				
Greenheart, 40 × $23\frac{1}{2}$, 153ft., 5s. to 5s. 6d.,		42 3 $9\frac{1}{2}$		
Sawing, £3; labour, 13 days at 5s., £3 5s.		6 5 0		
				48 8 $9\frac{1}{2}$
Masts, Fore, 80ft. × 30in., 500ft. cube. Main, $82\frac{1}{2}$ft. × 30in., $515\frac{7}{12}$ft. cube.				
Iron, $\frac{3}{8}$ & $\frac{7}{16}$in. thick.				
Plates	11 8 1 6	106 12 8		
Rivets	0 13 2 0	8 2 0		
Paints, oil, use of tools, &c.		14 15 8		
Wages		72 15 9		
	12 1 3 6		202 5 1	
16s. 9d. per cwt., or 4s. per cubic foot.				
Built Wood Masts, Fore, $91\frac{1}{2}$ft. × 31in. Main, $93\frac{1}{2}$ft. × 31in.				
Pitch pine, $1,381\frac{10}{12}$ft. at 2s. 6d.		172 14 7		
Cr. Plank, slabs, and cuttings off		22 14 3		
		150 0 4		
Oak for cheeks, 52ft. at 4s. to 3s.		7 17 0		
Bolts	0 15 3 $27\frac{1}{2}$—at 21s....	16 15 11		
Hoops	1 3 2 13—at 37s. 4d.	42 4 4		
White lead, paint, wedges, washers		7 18 0		
Wages, £37 10s. 2d.; sawing, £11 14s. 3d.		49 4 5		
				274 0 0
Masts, Mizzen $76\frac{1}{2}$ft. × 22in., $257\frac{1}{12}$ cub. ft.				
Iron, $\frac{3}{8}$ and $\frac{7}{16}$in. thick.				
Plates	3 16 1 14	35 11 8		
Rivets	0 5 1 0	3 10 5		
Paints, oil, use of tools, &c.		4 8 2		
Wages		21 4 10		
	4 1 2 14		64 15 1	
15s. 11d. per cwt., or 5s. per cubic foot.				
Wood Mast Tongued, 76ft. × $23\frac{1}{2}$in., $291\frac{5}{12}$ cubic ft.				
Main piece, pitch pine, 266ft. 4s. to 4s. 3d.		56 11 11		
Tongue piece, pitch pine, $39\frac{9}{12}$ft. at 2s. 6d.		4 19 4		
Bolts, paint, &c., £1 10s. 7d.; hoops, 2cwt. 6lbs. at 37s. 4d., £3 16s. 8d.		5 7 3		
Oak bib, 11ft., 2s. to 3s.		1 13 6		
Sawing, £1 9s. 4d.; wages, £7 10s.		8 19 4		
				77 11 4
			301 9 0	400 0 $1\frac{1}{2}$
Top-masts, Fore and Main, each 46ft. × 16in., $81\frac{9}{12}$ cub. ft. each. Mizzen, 38ft. × $13\frac{1}{2}$in., $48\frac{1}{12}$ cubic feet.				
Steel, $\frac{1}{4}$ and $\frac{3}{16}$in. thick.				
Puddled steel ...	3 6 0 14—at £18 10s.	61 3 4		
Iron rivets	0 4 2 10—at 15s. 6d.	3 11 6		
Paints, oil, use of tools, &c.		6 11 6		
Wages		28 10 5		
	3 10 2 24		99 16 9	
£1 8s. 3d. per cwt., or 9s. 5d. per cubic foot.				
Wood, pitch pine.				
Fore and Main, 50ft. × 18in. each, 225 cub. ft.; Mizzen, 40ft. × 15in., 62ft. = 287 cubic feet, 6s, to 2s. 6d.		35 18 9		
Sawing, £4 1s.; wages, 24 days at 5s. = £6		10 1 0		
				45 19 9
Lower Yards, Fore and Main, 77ft. × 19in. each, 193 cubic feet each. Crossjack, 60ft. × 15in., $93\frac{9}{12}$ cubic feet.				
Steel, $\frac{3}{16}$, $\frac{1}{4}$, and $\frac{5}{16}$in. thick		£ s. d.		
Puddled steel ...	5 3 1 15—at 13s. 6d.	92 17 1		
Rivets	0 6 3 5	5 18 5		
Paints, oils, use of tools, &c.		9 6 0		
Wages, including fitting jackstays		40 5 0		
	5 10 0 20		148 6 6	
£1 7s. per cwt., or 6s. 2d. per cubic foot.				
Carried forward			£549 12 3	£445 19 $10\frac{1}{2}$

		Iron and Steel. £ s. d.	Wood. £ s. d.
Brought forward		£549 12 3	£445 19 10½
Wood, pitch pine, Fore and Maiu scarfed.			
Main pieces, each 60ft. × 18in., 270 cubic feet at 4*s.* 6*d.*	60 15 0		
Short end pieces, each 30ft. × 15in., 93 cubic feet, 9*s.* to 2*s.* 3*d.*	10 10 11		
Hoops and bolts, 170lbs. at 6*d.*...............	4 5 0		
Sawing, £5 2*s.* 6*d.*; wages, 36 days at 5*s.* = £9..	14 2 6		
Crossjack, 62ft. × 16in., 103 cubic feet, 4*s.* to 3*s.* 6*d.*	18 1 8		
Sawing, £2; wages, 14 days at 5*s.* = £3 10*s.*	5 10 0		
			113 5 1

L ER TOP-SAIL YARDS, Fore and Maiu, each 66ft. × 16iu., $117\frac{4}{12}$ cubic feet each.
Mizzen, 51ft. × 12in., 51 cubic feet.

	T. cwt. qr. lb.		£ s. d.	Iron and Steel.	Wood.
Steel, $\frac{3}{16}$, $\frac{1}{4}$, and $\frac{5}{16}$in.					
Puddled steel ...	3 6 0 14	—at 18*s.* 6*d.*	61 3 4		
Rivets	0 5 3 20		4 13 6		
Paiuts, oils, usc of tools, &c.			5 9 2		
Wages, including fittingjackstays			23 4 6		
	3 12 0 6			94 10 6	

£1 16*s.* 3*d.* per cwt., or 6*s.* 7*d.* per cubic foot.

	£ s. d.	Iron and Steel.	Wood.
Wood, pitch pine, two, each 68ft. × 18in., 306 cubic feet at 4*s.* 6*d.*; one, 54ft. × 14in., 73 cubic feet, 6*s.* to 2*s.* 6*d.* = 379 cubic feet, 6*s.*..	78 0 9		
Sawing, £5 10*s.* 6*d.*; time, 41 days at 5*s.* = £10 5*s.*	15 15 6		
			93 16 3

UPPER TOP-SAIL YARDS, Fore aud Main, each 60ft. × 15in., $93\frac{9}{12}$ft. each.
Mizzen, 47ft. × 11in., $39\frac{6}{12}$ft.

	T. cwt. qr. lb.		£ s. d.	Iron and Steel.	Wood.
Steel, $\frac{3}{16}$, $\frac{1}{4}$, and $\frac{5}{16}$in. thick.					
Puddled steel ...	2 15 3 6	—at 18*s.* 6*d.*	51 12 4		
Rivets (Lowmoor)	0 3 0 11		4 17 10		
Paiuts, oils, use of tools, &c.			4 4 0		
Wages, including fitting jackstays			22 5 4	82 19 6	
	2 18 3 17				

£1 8*s.* 3*d.* per cwt., or 7*s*, 4*d.* per cubic foot.

	£ s. d.	Iron and Steel.	Wood.
Wood, pitch pine, two, each 66ft. × 16½in., 249 cubic feet, 6*s.* to 3*s.* 6*d.*; 50ft. × 12½, 54 cubic feet, 3*s.* to 2*s.* 6*d.* = 203 cubic feet at 9*s.*..	50 8 10		
Sawing, £3 7*s.*; wages, 38 days at 5*s.* = £9 10*s.*	12 17 0		
			63 5 10
		727 2 3	716 7 0½

"Showing a slight saving in favour of the use of wood masts and spars.

"Mr. Lawrie stated that the advautage in favour of steel and iron would be '*somewhat* modified by the changes that occur in the price of material,' but that the advantage would not be *usually* less than his figures indicated—namely, a saving to the shipowner of £500 on a ship of 1,000 tons, or 10*s.* per ton.

"I think the above rates may be taken as the *usual* rates, and that the present extremely high prices are without precedent, at least at this port. But allowing an addition for the present day's prices of £4 per ton on steel and iron, and from 2*s*, to 3*s.* 6*d.* per foot on the wood masts and spars, we will have—

	Iron and Steel. £ s. d.	Wood. £ s. d.
	727 2 3	716 7 0½
34tons 2cwts. 2qrs. 15lbs. irou and steel at £4 per ton...	136 10 6	
On wood masts aud spars, at from 4*s.* 6*d.* to 6*s.* 6*d.* per foot		352 11 10
	863 12 9	1068 18 10½

Showing at present day's rates a saving in favour of steel and iron of £205 6*s.* 1½*d.*

"Large irou lower masts are uudoubtedly cheaper than pitch pine or red pine ones, whether we take present or former days' rates. It is different, however, with the other spars. Iu the above list the

	£ s. d.
Steel and iron top masts and yards cost	425 14 3
Aud the wood ones	316 5 11
Excess in cost of steel and iron	109 8 4"

Referring to the foregoing statcment of cost of masts and spars, prepared by Mr. Hamilton, to show the experience of Messrs. Barclay, Curle, and Co., Mr. Lawrie states as follows:—

"Annexed is a note of the cost of iron and steel spars, and also of timber spars. With the exceptiou of the steel jib-boom, which I have uot made, all the other items of the cost of the iron and steel masts aud spars show the money paid in making the spars. The plates, rivets, &c., are put down at the invoice weights aud present prices, without deduction for scrap. The cost of the timber spars is put down at estimate cost, and on comparisou with the list of Mr. Hamilton, will be found to show, including the jib-boom, a lower price thau that of Mr. Hamilton, which does not include the jib-boom. A comparison, therefore, betwixt my price for iron and steel spars with that of timber spars is less uufavourable for the timber spars than according to Mr. Hamilton it should be. It is impossible, however, to make an estimate for timber spars with the same accuracy as for iron and steel, as it is impossible to know beforehand the size of logs that will be got of a quality suitable for the purpose. The sizes which I have put down in my list are the smallest that would answer, and are much smaller than in practice could generally be got. On that account my price for timber spars is considerably less than would generally be the cost. On the other hand, my iron and steel spars are all of them, with the exception of the lower masts aud bowsprit, of stcel, while in practice the lower yards, at all eveuts, are generally of iron, and eventually all the others will be so as well, for the reasou that, as it would be injudicious, on account of the security of the rivets, to reduce the thickness of the steel plates under the thickness iu my list, which is the usual thickness, they may fully better be made of iron, which, at the thickness of the steel plates, is sufficiently strong for the purpose, and is worked with fully more safety to the material. On that account the price of the iron aud stcel spars in my list is considerably greater than it ought to be, and hence a difference of £500 betwixt the iron and steel spars aud those of timber I believe to be accurate, or at all events as nearly so as the solutiou of such a question admits.

"The prices of material and wages put dowu in my list are present prices, with the exception of the wages of the carpeuters, which strictly should be put at 6*s.* pcr day iustead of 5*s.*, aud with respect to usual prices, the timber spars could hardly be put lower than 20 per cent. less for either material or wages, while for iron spars the material will certainly range 25 per cent. less, and the wages may be expected to be reduced by a still larger amount, considering that the men by whom the spars were made were paid at the following rates:—

Platers	5*s.* per day.
Rivetters...	4*s.* 6*d.* „
Caulkers	4*s.* 6*d.* „

and received in wages at these rates...	£114 16 3
and in profit upon their piece work	84 5 6
	£199 1 9 = Total cost of labour.

"No allowance is put iu my price for iron and steel spars, for coal or rent of machinery, because the scrap of the spars, for which no credit is given, is more than sufficient for that purpose, and a shipbuilder, in considering whether iron or timber is more economical for spars in producing a ship, will fecl satisfied with a very small allowance for rent.

	Weight. T. cwt. qr. lb.	Rate. £ s. d.	£ s. d.	Iron and Steel. £ s. d.	Timber. £ s. d.
Bowsprit = 30ft. 6in. × 28in.					
Plates, $\frac{7}{16}$ and $\frac{3}{8}$ (Iron)	2 0 0 0	0 13 0	26 0 0		
Rivets	0 1 3 0	0 14 0	1 4 6		
Workmanship of Fitting. No. of plates, 10	....	0 10 0	5 0 0		
Rivetting. No. of rivets, 550..........................	....	0 6 6	1 15 9		
Paring and Caulking. No. of yards, 33	....	0 0 6½	0 17 11	34 18 2	
Timber—Main piece, 33ft. × 30in. = 206ft..........	....	0 5 0	51 10 0		
Workmanship—Sawing, 720ft.	....	0 2 9	0 19 9		
Carpenters, 10 days	....	0 5 0	2 10 0		54 19 9
Carried forward......................	....	....	....	34 18 2	54 19 9

	Weight.	Rate.		Iron and Steel.	Timber.
	T. cwt. qr. lb.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Brought forward				34 18 2	54 19 9
FOREMAST = 77ft. 9in. × 30in.					
Plates, $\frac{7}{16}$ and $\frac{3}{8}$ (IRON)	4 19 2 15	0 13 0	64 15 3		
Cheeks and Angle Iron	0 4 1 14	0 13 0	2 16 10		
Rivets	0 5 0 0	0 14 0	3 10 0		
Workmanship of Fitting. No. of plates, 22		0 10 0	11 0 0		
Rivetting. No. of rivets, 1,600		0 6 6	5 4 0		
Paring and Caulking. No. of yards, 92		0 0 6½	2 9 10		
At Cheeks			3 0 0		
				92 15 11	
TIMBER—Main piece, 8 logs, 44ft. × 16½in. = 664 cubic ft.		0 4 0	132 16 0		
Cheeks, 30 cubic ft.		0 5 0	7 10 0		
Bolts	0 5 0 0	0 0 2	4 13 4		
Hoops, = 4½ × $\frac{3}{8}$, spaced at 3ft.	0 6 0 0	0 0 4	11 4 0		
Workmanship—Sawing, 2,900ft.		0 2 9	3 19 9		
Carpenters, 108 days		0 5 0	27 0 0		
					187 3 1
MAINMAST = 82ft. × 30in.					
Plates, $\frac{7}{16}$ and $\frac{3}{8}$ (IRON)	5 3 1 21	0 13 0	67 4 8		
Cheeks and Angle Iron	0 4 1 26	0 13 0	2 18 3		
Rivets	0 5 1 7	0 14 0	3 14 4		
Workmanship of Fitting. No. of plates, 23		0 10 0	11 10 0		
Rivetting. No. of rivets, 1,700		0 6 6	5 10 6		
Paring and Caulking. No. of yards, 98		0 0 6½	2 13 1		
At Checks			3 0 0		
				96 10 10	
TIMBER—Main piece, 8 logs, 48ft. × 16½in. = 726 cubic ft.		0 4 0	145 4 0		
Cheeks, 30 cubic ft.		0 5 0	7 10 0		
Bolts	0 5 1 23	0 0 2	5 1 10		
Hoops, 4½ × $\frac{3}{8}$, spaced 3ft.	0 6 2 25	0 0 4	12 11 0		
Workmanship—Sawing, 3,200ft.		0 2 9	4 8 0		
Carpenters, 108 days		0 5 0	27 0 0		
					201 14 10
MIZZENMAST = 71ft. 9in. × 23in.					
Plates, $\frac{7}{16}$ and $\frac{3}{8}$ (IRON)	3 10 0 12	0 13 0	45 11 4		
Cheeks and Angle Iron	0 2 3 3	0 13 0	1 16 1		
Rivets	0 4 2 21	0 14 0	3 5 7		
Workmanship of Fitting. No. of plates, 20		0 10 0	10 0 0		
Rivetting. No. of rivets, 1,500		0 6 6	4 17 6		
Paring and Canlking. No. of yards, 82		0 0 6½	2 4 5		
At Cheeks			2 10 0		
				70 4 11	
TIMBER—Main piece, 8 logs, 41ft. × 14in. = 448 cubic ft.		0 3 0	67 4 0		
Cheeks, 20 cubic ft.		0 5 0	5 0 0		
Bolts	0 3 3 0	0 0 2	3 10 0		
Hoops	0 4 2 0	0 0 4	8 8 0		
Workmanship—Sawing, 2,175ft.		0 2 9	2 19 10		
Carpenters, 81 days		0 5 0	20 5 0		
					107 6 10
JIBBOOM = 57ft. × 17in. (STEEL)					
Plates, $\frac{5}{16}$ and $\frac{1}{4}$	1 2 0 0	1 0 0	22 0 0		
Rivets	0 1 1 20	0 15 0	1 2 10		
Workmanship of Fitting. No. of plates, 10		0 10 0	5 0 0		
Rivetting. No. of rivets, 800		0 7 6	3 0 0		
Paring and Caulking. No. of yards, 46		0 0 5	0 19 2		
				32 2 0	
TIMBER—Main piece, 60ft. × 19in. = 150ft.		0 5 0	37 10 0		
Workmanship—Sawing, 750ft.		0 2 9	1 0 7		
Carpenters, 9 days		0 5 0	2 5 0		
					40 15 7
FORE TOPMAST.					
Plates, $\frac{5}{16}$ and $\frac{4}{16}$ (STEEL)	1 1 3 4½	1 0 0	21 15 9		
Rivets	0 1 0 24	0 16 0	0 19 5		
Lowmoor Plate	0 1 1 4	1 3 6	1 10 3		
Workmanship of Fitting. No. of plates, 10		0 10 0	5 0 0		
Rivetting. No. of rivets, 680		0 7 6	2 11 0		
Paring and Caulking. No. of yards, 35		0 0 5	0 14 7		
Lowmoor Plate			1 0 0		
Sheave Holes			2 0 0		
				35 11 0	
TIMBER—Main piece, 46ft. × 19in. = 115ft.		0 4 0	23 0 0		
Workmanship—Sawing, 560ft.		0 2 9	0 15 5		
Carpenters, 10 days		0 5 0	2 10 0		
					26 5 5
MAIN TOPMAST, 44ft. × 17in.					
STEEL—same as Fore Topmast				35 9 11	
TIMBER—same as Fore Topmast					26 5 5
MIZZEN TOPMAST, 34ft. 8in. × 3ft.					
Plates, $\frac{5}{16}$ and $\frac{4}{16}$ (STEEL)	0 13 1 24	1 0 0	13 9 3		
Rivets	0 0 3 16	0 16 0	0 14 3		
Lowmoor Plate	0 0 2 10	1 3 6	0 13 10		
Carried forward				397 12 9	644 10 11

	Weight.	Rate.		Iron and Steel.	Timber.
	T. cwt. qr. lb.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Brought forward				397 12 9	644 10 11
Workmanship of Fitting. No. of plates, 8		0 10 0	4 0 0		
Rivetting. No. of rivets, 500		0 7 6	1 17 6		
Paring and Caulking. No. of yards, 26		0 0 5	0 10 10		
Lowmoor Plate			0 10 0		
Sheave Holes			2 0 0		
				23 15 8	
Timber—Main piece, 36ft. × 15in. = 56ft.		0 2 6	7 0 0		
Workmanship—Sawing, 350ft.		0 2 9	0 9 8		
Carpenters, 6 days		0 5 0	1 10 0		
					8 19 8
Fore-yard, 74ft. 9in. × 18½in.					
Plates, 5/16, 4/16, and 3/16in. (Steel)	1 12 2 10	1 0 0	32 11 9		
Rivets	0 1 3 24	0 16 0	1 11 5		
Workmanship of Fitting. No. of plates, 16		0 10 0	8 0 0		
Rivetting. No. of rivets, 1,100		0 7 6	4 2 6		
Paring and Caulking. No. of yards, 60		0 0 5	1 5 0		
				47 10 8	
Timber—Main piece, 80ft. × 20in. = 224ft.		0 6 0	67 4 0		
Workmanship—Sawing, 1,440ft.		0 2 9	1 19 7		
Carpenters, 8 days		0 5 0	2 0 0		
					71 3 7
Mainyard, 74ft. 9in. × 18½in.					
Steel—same as Foreyard				47 10 6	
Timber—same as Foreyard					71 3 7
Mizzenyard, 58ft. × 14½in.					
Plates, 5/16, 4/16, and 3/16in. (Steel)	0 19 0 15	1 0 0	19 2 8		
Rivets	0 1 1 20	0 16 0	1 2 10		
Workmanship of Fitting. No. of plates, 12		0 10 0	6 0 0		
Rivetting. No. of rivets, 800		0 7 6	3 0 0		
Paring and Caulking. No. of yards, 45		0 0 5	0 18 9		
				30 4 3	
Timber—Main piece, 61ft. × 16½in. = 116ft.		0 5 0	29 0 0		
Workmanship—Sawing, 750ft.		0 2 9	1 0 7		
Carpenters, 6 days		0 5 0	1 10 0		
					31 10 7
Fore Lower Topsail-yard = 62·6 × 15½in.					
Plates, 5/16, 4/16, and 3/16in. (Steel)	1 1 3 4½	1 0 0	21 15 10		
Rivets	0 1 2 12	0 16 0	1 5 9		
Workmanship of Fitting. No. of plates, 14		0 10 0	7 0 0		
Rivetting. No. of Rivets, 900		0 7 6	3 7 6		
Paring and Caulking. No. of yards, 48		0 0 5	1 0 0		
				34 9 1	
Timber—Main piece = 65ft. × 17½in. = 138ft.		0 6 0	41 8 0		
Workmanship—Sawing, 1,047ft		0 2 9	1 8 10		
Carpenters, 7 days		0 5 0	1 15 0		
					44 11 10
Main Lower Topsail-yard, 62ft. 6in. × 15½in.					
Steel—same as Fore Lower Topsail-yard				34 9 3	
Timber—same as Fore Lower Topsail-yard					44 11 10
Fore Upper Topsail-yard, 58ft. 9in. × 14½in.					
Plates, 5/16, 4/16, and 3/16in. (Steel)	1 0 1 7½	1 0 0	20 6 4		
Rivets	0 1 1 16	0 16 0	1 2 3		
Workmanship of Fitting. No. of plates, 12		0 10 0	6 0 0		
Rivetting. No. of rivets, 780		0 7 6	2 18 6		
Paring and Caulking. No. of yards, 44		0 0 5	0 18 4		
				31 5 5	
Timber—Main piece, 61ft. × 16½in. = 116ft.		0 5 0	29 0 0		
Workmanship—Sawing, 750ft.		0 2 9	1 0 7		
Carpenters, 6 days		0 5 0	1 10 0		
					31 10 7
Main Upper Topsail-yard, 58ft. 9in. × 14½in.					
Steel—same as Fore Upper Topsail-yard				31 5 6	
Timber—same as Fore Upper Topsail-yard					31 10 7
Mizzen Topsail-yard, 45ft. × 11¼in.					
Plates, 5/16, 4/16, and ¾in. (Steel)	0 12 1 27	1 0 0	12 9 10		
Rivets	0 1 0 4	0 16 0	0 16 6		
Workmanship of Fitting. No. of plates, 10		0 10 0	5 0 0		
Rivetting. No. of rivets, 580		0 7 6	2 3 6		
Paring and Caulking. No. of yards, 34		0 0 5	0 14 2		
				21 4 0	
Timber—Main piece, 47ft. × 13in. = 55ft.		0 2 6	6 17 6		
Workmanship—Sawing, 550ft.		0 2 9	0 15 2		
Carpenters, 4 days		0 5 0	1 0 0		
					8 12 8
				699 7 1	988 5 10
Less for Jib-boom, not included by Mr. Hamilton				32 2 0	40 15 7
				667 5 1	947 10 3

MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last ordinary monthly meeting of this associatiou was held on August 30th. The chief engineer presented his report, of which the followiug is an abstract:—

"During the last montb 298 engines have been examined, and 516 boilers, 31 of the latter being examined specially, and 2 of them tested with hydraulic pressure. Of the boiler examinatious, 440 bave been external, 12 internal, and 64 thorough. Iu the boilers examined, 167 defects have been discovered, 2 of them being dangerous. Details of these will be found in tbe following tabular statement:—

FROM JULY 23RD, 1864, TO AUGUST 26TH, 1864, INCLUSIVE.

DESCRIPTION.	Number of Cases met with		
	Dangerous.	Ordinary.	Total.
DEFECTS IN BOILER.			
Furnaces out of shape	...	3	3
Fracture	...	4	4
Blistered Plates	...	1	1
Corrosion—Internal	2	5	7
Do. External	...	7	7
Grooving—Internal	...	5	5
Do. External	...	2	2
Total number of Defects in Boiler	2	27	29
DEFECTIVE FITTINGS.			
Feed Apparatus Out of Order	...	...	...
Water Gauges ditto	...	7	7
Blow Out Apparatus ditto	...	17	17
Fusible Plugs ditto	...	2	2
Safety Valves ditto	...	8	8
Pressure Gauges ditto	...	15	15
Total number of Defective Fittings	...	49	49
OMISSIONS.			
Boilers without Glass Water Gauges	...	4	4
Ditto Pressure Gauges	...	37	37
Ditto Blow Out Apparatus	...	9	9
Ditto Feed Back Pressure Valves	...	39	39
Total Number of Omissions	...	89	89
Cases of Over Pressure	...	...	...
Cases of Deficiency of Water	...	...	...
Gross Total	2	165	167

EXPLOSIONS.

"I have to report for the present month the explosion of four boilers employed for steam purposes, by which six persons have been killed and six others injured. Not one of these boilers was under the inspection of this Association; while two of them have been personally examined since their explosion.

"It may perhaps also be stated, tbat another explosion, resulting in the death of three men, as well as injury to several others, happened at a gas-works to the tar boiler of a naptha still. This boiler was heated by a fire underneatb it, and in addition—in order to liquify the tar at starting, so as to keep the bottom of the boiler from burning—it was fitted witb an internal coil of steam pipe. It had not outlet for the gases or vapours evolved ou tbe evaporation of the tar other than through a spiral worm, in which they were condensed, and which was of considerable length, consisting of 14 coils. This worm was made of lead, and was connected to a boiler by a length of cast iron pipe. This pipe became choked up with a deposit of amoniacal salts, which were foreign to the process of manufacture, and introduced into the tar by accident. The attendant observed that the naptha ceased to flow from the still, but, as it frequently came in plunges rather than in a regular stream, he did not suspect that anything was wrong, and, not having any pressure gauge to his boiler, had no means of kuowing that the stoppage was not caused by the insufficiency of his draught, which it appears was a poor one; he therefore continued to charge his fire when he ought to have withdrawn it altogether, and the boiler in consequence shortly burst asunder from accumulated pressure within it. It is not customary in stills of this character to supply them with any safety valve or pressure gauge, as considerable difficulty is met with in applying them, so tbat their safety depends entirely on the freedom of the outlet for the gases and liquids. Since, however, this is apt to become clogged, and in one case at all events, as in the present instance, has become hermetically sealed, it would appear that it is an arrangement that deserves the most urgent re-consideration.

"TABULAR STATEMENT OF EXPLOSIONS.

FROM JULY 23RD, 1864, TO AUGUST 26TH, 1864, INCLUSIVE.

Progressive No. for 1864.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
20	July 29	Details not yet ascertained	0	0	0
21	„ 30	Cylindrical egg-ended. Externally fired	3	0	3
22	Aug. 16	Locomotive	1	1	2
23	„ 18	Vertical multitubular. Internally fired	2	5	7
		Total	6	6	12

"No. 21 explosion took place at a colliery, and, from the number of persous killed and the circumstances connected with it, excited a good deal of interest. I visited the scene of the catastrophe soon after the explosion occurred, and since then the proprietors of the works have kindly furnished me with a model of the exploded boiler, as well as a plau of the works, with specimens of the plate, while I am also furnished with a copy of the report made upon tbe explosion by the Government Inspector of Mines for the district. These were not, however, received in sufficient time to give them that consideration which they merit before the issue of this report, and, therefore, further notice of this explosion is deferred to the next opportunity.

"No. 23 explosion occurred at an engine builder's, and by it two persons were killed and five otbers injured. The boiler was not under the inspection of this Association.

"The boiler was a new one, not having worked more than nine months. It was of vertical tubular construction, with a self-contained internal furnace, the flames passing upwards through the tubes and the water surrounding them. These tubes at their upper end were attached to a cylindrical smoke box contained within the boiler, and since the tube plate was below the water line, the tubes were entirely immersed when the boiler was filled to the working level. The shell was cylindrical, but not of one diameter throughout, being enlarged at the upper part so as to admit of the introduction of the smoke box just referred to, and also to afford more steam space, as well as a greater area of water surface. The larger cylindrical portion at the top of the boiler was attached to the remainder of the shell by means of a flat annular plate; while a similar annular plate completed the connection between it and tbe smoke box on tho top, the latter plate being stiffened with four substantial gusset stays tying it to the outer shell. These flat anuular plates are particularly referred to siuce they are not very generally introduced in this description of boiler, and it becomes worthy of consideration whether they have had any influence or not upon the cause of this explosion. None of tbe plates were flanged, angle irons being used throughout and these not welded into entire riugs but jump jointed. The extreme height of tbe boiler was 15ft. 7iu.; while that up to the set-off at the enlargement for the steam space was 10ft. 3in., and of the steam spacc itself 5ft. 4in. The diameter of the lower portion of the shell was 4ft. 7in., and of the upper steam space 7ft.; while the width of the lower flat annular plate was 15in., and that of the upper one 18in. The thickness of the cylindrical part of the steam chamber and smoke box was seven-sixteenths of an inch, and the remainder three-eighths of an incb; while that of the flat aunular plates one half of an inch. The tubes were 4ft. 9in. in length, $1\frac{3}{4}$in. in diameter, and 117 in number; while there were 4 vertical staybolts $1\frac{1}{2}$in. in diameter between the two tube plates.

"The boiler was fitted with two safety valves, one a lock-up valve of 3in. diameter, loaded to $70\frac{1}{4}$lb. per square inch, and the other an ordinary open lever safety valve, $3\frac{1}{2}$in. diameter, loaded to $66\frac{3}{4}$lb. per square incb. There was also a glass water gauge, a dial steam pressure gauge, &c.

"The rents in the boiler had all occurred in the enlargement for the steam space at the top, the cylindrical portion of the chamber being completely stripped off all tbe way round and rent, not only at two or more of the vertical seams of rivets, but also at the circular oue at the top as well as at the bottom. This strip of plating was flattened out and blown away from the boiler; while the other part of the shell held together, the lower flat annular plate, however, being considerably bent downwards, and tbe upper one slightly upwards; while many of the tubes were blown outwards, and tbe majority drawn out of the tube plates. Notwithstanding this, however, tbe boiler retained its vertical position, and was only displaced a few feet, and partially twisted round.

"The boiler was so closely hemmed in by buildings that the injury to the surrounding property was considerable, and it was by the fall of the ruins that one of the lives was lost.

"The cause of the explosion was investigated by two engineers of considerable repute, one of them baving been for many years at the head of a large engineering firm engaged in building locomotive and marine engines, and the other occupying at the present time the position of manager at a large iron-works, where a considerable number of boilers, of very similar construction to tbe exploded one, are working. These engineers, both of whom examined the boiler after its explosion, and tested the quality of the plates, agreed in their conclusions with regard to it. They considered that the material and workmanship were both good, and that the boiler had been altogether faithfully made in the first instance; also, that it was suitably mounted, the safety valves and other fittings being adequate. Further, that it was perfectly safe at its ordinary working pressure of 70lb. per square inch, or, indeed, at a higher one; while they

had detected no signs of wear, but found the platcs to be in sound condition. On consideration of all the circumstances, they attributed the explosion to excessive pressure; a pressure considerably above that at which the boiler was usually worked. They had not, however, discovered the cause of that excessive pressure, but thought it might possibly have been due to overloading of the safety valve.

"The boiler attendant gave it in evidence, that he had examined it a few minutes before the explosion, and found that there was plenty of water in the glass gauge, and that the whole was in correct working order. The foreman boiler-maker stated, that the boiler had been made of the best materials, and that everything conducive to its safety had been attended to in its construction. He considered that the boiler was amply sufficient for the work it had to do; had never heard a complaint with regard to it, or noticed any defect, or even the slightest leakage in it, and could assign no reason whatever for its explosion.

"On examining the boiler myself, I formed the same opinion as to the quality of the materials and workmanship as that already given, viz., that they were very good, while there were no signs whatever that the boiler had been allowed to run short of water, the smoke box and the upper part of the tubes being quite sound, and coated with a thin film of scale.

The manner in which the boiler had rent certainly appeared to result from excessive pressure; but, on the other hand, there is no evidence to show that the safety valves had been tampered with, and no ordinary overloading would have attained to the bursting pressure of this boiler, or anything approaching to it; while the attendant stated, that the steam gauge indicated only the ordinary pressure a few minutes before the explosion occurred, and that one of the safety valves was blowing off at the time.

"With regard to the strength of the flat annular plates, those were uninjured in themselves, except by the result of the explosion, and should then, by their deflection under steam, have thrown undue strain upon the cylindrical portion of the shell to which they were attached, and thus have started the rent that ran round the ring seam of rivets, yet it is difficult to see how this could have developed into a rent at the vertical seams as well. Transverse seam-rending is by no means uncommon, but it is not usual for it to affect the longitudinal seams. The science of boiler-making is somewhat in arrears with regard to the strength of flat plates when firmly secured at the outer edges, especially when of irregular shape. It is true that investigations have been made with regard to the strength of the flat sides of locomotive fire-boxes when stayed at regular distances, but these conditions do not apply to all cases, and there is evidently room for further researches. Doubtless the flat ends of internally-fired boilers are now amply secured by gusset-stays, but that has rather been arrived at by practice, and a desire to be on the safe side, than by any clearly ascertained rule, so that it frequently becomes a question, and one that causes a good deal of anxiety, as to whether a flat surface in a boiler, at all out of the ordinary routine is safe or not.

"In conclusion, although it may be difficult, now that the explosion has occurred, and the boiler has been partially destroyed, as well as a portion of the surrounding premises laid in ruins, to trace out the precise train of circumstances that led to this explosion, it must not on that account be concluded that its cause was mysterious. Explosions are never capricious, but always obey fixed laws, and it is only on account of our own defective powers of research that we cannot in every case promptly determine the course they have taken. It may yet be detected that the safety valve was hampered, or that some hidden flaw, which has hitherto baffled examination, had lurked in the plates. In the meantime our members cannot do better than persist with full confidence in the exercise of dve care in the management of their boilers, as the only preservative against explosion in their own case."

REVIEWS AND NOTICES OF NEW BOOKS.

Pocket-Book of Practical Rules for the Proportions of Modern Engines and Boilers for Land and Marine Purposes. By N. P. Burgh, Engineer. London: E. and F. N. Spon. 1864.

This very handy-sized book—which has been got up to match that most useful little work of its class, Molesworth's "Pocket-Book of Engineering Formulæ," also issued by the same publishers—is a creditable production, and will be found of considerable service to the engineering student; and after a careful perusal of Mr. Burgh's Practical Rules, &c., we are of opinion that the book must very soon reach a second or even a third edition, to enable the author to perfect the collection of useful practical rules which in this first edition he has strung together.

The present work renders his previously published "Practical Illustrations of Modern Land and Marine Engines" complete as a work of reference, as part of the work now under notice appears to be a statement of the details, dimensions, and proportions of the parts of the engines and machinery illustrated in the folio plates recently published, and which were noticed in The Artizan for September last.

Mr. Burgh's "practical rules" will be found useful in the workshop and drawing office, and although there are some crudities in the present edition of Mr. Burgh's little book, which will no doubt be hereafter got rid of, as they arise chiefly from want of that knowledge which bookmakers at starting most lack; but we advise Mr. Burgh to follow up the task he has undertaken, and we trust he may succeed.

Locomotive Engineering, and the Mechanism of Railways; a Treatise on the Principles and Construction of the Locomotive Engine, Railway Carriages, and Railway Plant. Illustrated with sixty large engravings and numerous woodcuts. By Zerah Colburn, C.E. Glasgow: William Colland, 139, Stirling-road. Edinburgh: 37, Cockburn-street. London: 43, Paternoster-row. 1864.

Received too late this month to permit of a notice in the present number.

NOTICES TO CORRESPONDENTS.

J. L. W. (India).—1. The engines of the vessel to which you refer have high and low pressure cylinders. The collective horse-power is 2,486 indicated. 2. We have prepared a notice and illustrations of the subject upon which you wrote us, but want of space compels us to defer giving these till our next issue.

"Amateur."—We have in course of preparation copperplate engravings of the engines to which you refer; these will be given in an early issue, when we will also give the full dimensions.

W. E. B.—Your question shall be answered in our next.

D. Dalgleish, Esq., M.L.A. (Sydney, N.S.W.).—Thanks for the information and documents forwarded by you; they shall have attention.

A. Subscriber (Brest).—There is nothing recently published on moulding and founding; but Messrs. E. and F. N. Spon will supply you with Overman's "Treatise," price 5*s*., and Campin's "Mechanical Engineering," 27*s*.

C. P. D.—The last new locomotives, the middle class express engines of the Brighton Railway, from designs by Mr. Crabb, the Locomotive Engineer of the Company, weigh 31 tons 12 cwt., distributed thus:—Leading wheel, 10 tons 14 cwt.; driving, 13 tons 10 cwt.; trailing, 7 tons 8 cwt. The weight of the tender when full is 20 tons 19 cwt., or together, engine and tender, 52 tons 11 cwt. The tender contains 1,650 gallons, which is rather more than the quantity of water required for taking a train of 30 carriages the 52 miles at express speed. The heating surface is 870 square feet in the 153 tubes, and 91 square feet in the fire-box, together 961 square feet.

Vapour.—There have been several such engines described in philosophical works, but one of the most recent of this kind is one invented by a German, which was submitted to M. Tresca, of Paris, in which a series of hollow arms having spherical terminations, were connected with the same axis, and alcohol or ether was employed. Some years ago, a Russian inventor, Prince Rondanzon, had a somewhat similar contrivance, but he produced, primarily, a reciprocating motion by the alternate vaporization and condensation of alcohol contained in the vessels.

W. H. G. (Palermo).—The communication respecting which your son has applied to us has never been received. Shall be glad to have a duplicate.

J. G., W. M., and H. H. (Lisbon); W. B. and J. R. (Madrid); A. C. G. (Zaragoza); O. D., G. T., and others (Trieste); J. C. C (Marseilles); E. A. P. (Vienna); M. Rap (Palermo); J. C. R. (Constantinople); and H. C. (Smyrna).—Your communications received, and will be duly attended to.

J. S. (1, Partington-terrace, Varley-street, Manchester).—We await your further information.

J. Cameron.—Your request will be attended to.

C. S. (Milton-street, Stockport).—We shall be glad to receive fuller information.

Breech Loader.—We cannot furnish you with the information.

R. S.—You will find the required information in Professor Eaton Hodgkinson's, Fairbairn's, Kirkaldy's, and similar works on iron and steel. If, however, you will state the purposes to which you intend to apply the iron, and send us your address, we will forward you the exact information to suit the particular application you have in view.

S.—It so happens that we have recently received from an engineer in India a design somewhat similar to that you have furnished, and Mr. Watson, C.E., the designer, has, we believe, put the arrangement into use in some locomotive engines under his charge.

H. B. S., Mannantoddy (Madras).—We cannot undertake to supply the information, unless you state the *quantity of water* you require to be delivered. Send us also a sketch of the arrangement you propose.

C. F. S.—There is no better book to be found treating of those manufactures to be found on the River Tyne than the book published by A. Reid, Newcastle, which, besides treating of the subject in question, very fully developes, in a most interesting manner, the industrial resources of the Rivers Tyne, Wear, and Tees. It is edited by Sir W. G. Armstrong, I. L. Bell, John Taylor, and Dr. Richardson. It has already passed through a second edition. You will find in it all you require.

D. R.—Judging only by your very imperfect description of the invention the same thing appears to have been done and patented already. Amongst others who have a simple plan of communicating between guard and engine-driver and the passengers and engine-driver or guard of a railway train is a Mr. Furrell, a nephew of Mr. John Seaward.

X. X.—The locomotive expenditure on the Great North of Scotland Railway as well, indeed, as the other items of charges against revenue account, contrast favourably with other lines whether north or south of the Tweed. We can obtain for you much of the information you seek but it will involve considerable expense.

D. C. L.—There is a Parliamentary return (of working expenditure and working stock) published annually in a Blue Book which you may obtain by applying to Mr. King, Parliament-street, Westminster.

NOTES AND NOVELTIES.

MISCELLANEOUS.

The New Magnesium Light.—The great difficulty which has hitherto stood in the way of the utilisation of this very brilliant light has been the want of some means for its easy application. This difficulty is said to be now entirely surmounted. Mr. A. G. Grant, an American gentleman, resident at Nottingham, has patented an apparatus for effecting the object in view. The wire is coiled on spools, and thence is drawn between cylinders to a tube through which it is said to be thrust at precisely the rate at which it burns. The apparatus will form a hand-lamp, or may be applied for other purposes—such as the lighting of theatres, the making of fog-signals, or signals of any kind. The hand-lamp will be especially useful to photographers. The increasing cheapness of the magnesium wire may soon cause it to be generally adopted where a very brilliant light is required

Welding by Hydraulic Pressure.—A series of experiments have lately been made at Paris by M. Duportail, engineer, in the workshops of the Western Railway, to ascertain whether iron might be welded by hydraulic pressure instead of by the sledge-hammer. The latter, indeed, has not a sufficient impetus to reach the very core of the metal, while continuous pressure acts indefinitely to any depth. In the experiments alluded to, M. Duportail caused two iron bars, 1½in. in diameter, and heated to the welding point, to be placed between the piston and the top of an hydraulic press. The bars were welded together by this means with extraordinary ease, the iron being, as it were, kneaded together, and bulged out at the sides under the pressure. The action of the press was suspended when the part welded was brought down to the thickness of the bars. After cooling, the welded part was cut through to examine the inside, which was found perfectly compact. To try it, one of the halves was placed under a forge-hammer weighing 1,800 kil., and it was not until the third stroke that the welding was discovered.

The Iron Trade.—In consequence of the demand for British iron in the United States, a considerable increase has been observable in the exports of iron of various kinds during the last two years. The value of the exports shows an immense increase, having been £6,996,510 this year, against £5,916,867 in 1863, and £5,071,354 in 1862.

Erosion of Lead by Insects.—The fact that there are insects of different species which bore into lead has been heretofore known, but a correspondent of the *Times* recalls attention to the subject in a *resumé* of proceedings as to it in the *Comptes Rendus*. The insect which bored French bullets in the Crimea was not known in Russia, but is said to be common in the Jura, in France, and in Germany and Sweden, as well as in England. It is a wood insect, and usually attacks silver firs and pines. It is the larvæ of the insect which attacks the lead—not the perfect insects, which die in the excavated passages even immediately after the metamorphosis, as very often occurs with insects in general. Roof and other sheet lead has been known to be bored by a species of Bostriche (*B. Capucina*). The *Sirex gigas* also often cuts its way into lead by means of its mandibles, as also the *Callidium sanguineum*; and lead pipes have been perforated by an insect named *Apate humeralis*. The mandibles of some of these insects consist of a saw, toothed and cut like a file. Perforations in lead ascribed to corrosion may sometimes be the product of the mischievous industry of such insects.

India-rubber Packing for Stuffing Boxes.—The stuffing supplied by Unger's india-rubber manufactory, Berlin, consists of washers of various diameters, made up alternately of layers of sail cloth and vulcanized india-rubber, rolled together and compressed in a compact mass. By using this packing, the irregularities in the motion and the escape of steam attending the application of the common hemp packing are entirely suppressed. Its durability is four or five times, its price about twice, that of the common packing. Herr Jacob, engineer of Hettstadt, has applied this packing with great advantage to a 20 horse-power steam engine, working at a pressure of about 25lbs. per square inch, and making 14 or 15 revolutions per minute.

Wool Spinning.—M. Lepainteur has taken out a patent in Belgium for making useful petrolem or benzoin oils and essences, for the scouring of wool. He applies the usual process of extracting the greasy matter, by pouring into the scouring waters sulphuric acid in the proportion of ⅗lb. for every pound of oil operated upon. The greasy matter is then removed from the surface of the bath, a quantity of chlorhydric acid, corresponding to 1-20th part of the oil is added. The whole is poured into a boiler furnished with a double bottom or double jacket, and heated by steam to a temperature of from 212° to 248° F, so as to evaporate the little water remaining in the oil. The heat also furthers the action of the chlorhydric acid, which, carbonises the foreign matter, whether animal or vegetable, which then falls to the bottom of the boiler, and is readily removed from thence as a deposit. By adding to the product 5 per cent. of oil or essence of petroleum or benzoin, when using it, an oiling substance of superior quality is obtained, which acts advantageously on the wools and breakers, by preserving their teeth and facilitating the clearing.

The London Coal Trade.—For the month of August just ended 443,852 tons 13 cwt. of coal were entered at the metropolis per railway, canal, and seaborne as against 414,283 tons 16 cwt. for the same month of 1863. The seaborne arrivals were in the following proportions:—Newcastle, 103,404 tons in 211 ships; Seaham, 10,343 tons in 48 ships; Sunderland, 78,764 tons in 187 ships; Middlesborough, 6,185 tons in 25 ships; Hartlepool and West Hartlepool, 43,285 tons in 162 ships; Blyth, 524 tons in two ships; Scotch, 1,967 tons in 16 ships; Welsh, 11,151 tons in 28 ships; Yorkshire, 1,302 tons in 16 ships; 3,763 tons small coal in 7 ships, and 612 tons cinders in 6 ships. Of this large tonnage 121,595 tons are various sorts of Wallsend, 23,879 tons are gas, and 8,799 tons steam coal. The railways have brought the undermentioned tons:—London and North-Western, 82,094 tons 5 cwt.; Great Northern, 54,777 tons; Great Western, 20,232 tons; Great Eastern, 12,602 tons 12 cwt.; Midland, 8,347 tons 17 cwt. to the St. Pancras depot, and 1,395 tons 2 cwt. to the King's-cross coal station; South-Western, 1,557 tons 15 cwt.; London, Chatham, and Dover, 205 tons 12 cwt.; and Tilbury and Southend, 30 tons, making a total of 181,242 tons 3 cwt., against 142,110 tons 17 cwt. for August, 1863. Of this weight 11,000 tons was of the Silkstone qualities; 15,635 tons from the Clay-cross pits, near Chesterfield, and 3,559 tons of coke. For the eight months of the present year the entries have been—by railway, 1,497,434 tons 13 cwt., against 1,069,655 tons 13 cwt., showing an increase of 427,778 tons 15 cwt. The canal supply has declined from 6,593 tons 5 cwt. for the first eight months of 1863 to 6,261 tons for the present year. The seaborne coal entered for the same period was 2,117,618 tons in 5,738 ships, against 2,109,107 tons in 6,264 ships for the corresponding months of last year, showing an increase in the tonnage of 8,541 tons, but a decline in the number of ships of 526. The total tonnage for the present year, from all sources, has been 3,621,343 tons 13 cwt., against 3,185,355 tons 18 cwt. from the 1st of January to the 31st of August, 1863.

Improved Steam Valve.—Mr. W. H. Akins, of Dryden, New York, has invented a valve, which consists in a solid plug, provided with a cavity, and fitted in a case surrounded by an annular steam chamber, furnished with three or more ports, and divided off in three or more separate compartments—one to communicate with the interior of the cylinder, one with the steam, and another with the exhaust pipe—in such a manner that the plug is relieved from all, or nearly all, pressure of steam, and, therefore, can be moved instantaneously, and by turning the said plug over the small arc the interior of the cylinder can be brought to communicate either with the steam or with the exhaust pipe as circumstances require.

Steam Engines in Prussia.—From an official return recently issued it appears that the total number of steam engines at the end of 1862 was 8,653, with 365,707 horse-power, showing an increase of 5,821 engines and 273,243 horse-power, as compared to 1852, when there were only 2,832 engines, with a total of 92,462 horse-power.

A New Thermograph.—M. Marcy has addressed to the Academy of Sciences the following description of an instrument for marking small variations of temperature:—1. The first part of this thermograph consists of a copper tube a metre in length, the interior diameter of which is capillary, not being more than one-fifth of a millimetre. It is open at one end, and soldered to a hollow copper ball at the other end. 2. The second part of the apparatus consists of a wheel resting upon knife-edges, like those of a pair of scales, whereby a very delicate oscillation may be imparted to it. The axle of the wheel carries a long vertical needle, marking the degrees on a circular scale. To the circumference of the wheel is fixed a glass tube six millimetres in diameter, and bent in conformity to the curvature of the wheel, and so situated that the middle of the tube lies vertically underneath the needle when the wheel is at rest. One of its extremities is hermetrically closed, while the other is open. Now, if a little mercury be poured into this tube it will settle at the lowest point, and the interior of the tube will thus be divided into two chambers, one closed and with air confined in it, the other open. 3. Now introduce the copper tube into the glass one, giving it of course the same curvature, and so that its extremity may pass through the mercury, thus establishing a communication between the hollow copper ball and the confined chambers, and the apparatus, with a few accessory appliances, will be complete. The end of the copper tube dipping into the mercury should be varnished to prevent its being attacked by the latter metal; or better still, the end might be made of platinum. 4. To use this apparatus, put your hand to the copper ball; the warmth thus imparted to it will dilate the air it contains, and drive part of it into the confined chamber; the mercury will therefore recede, and thereby make the wheel turn round its centre of gravity; the very small arc thus described will be revealed by the needle, the difference of its present position with its previous one when at rest. If, on the contrary, the copper ball be cooled, by water for instance, the air inside will be contracted, a portion of the air of the confined chamber will rush in, and the mercury will be driven forward, the needle turning in the inverse direction. By means of this apparatus very delicate physiological experiments on animal heat may be conducted.

NAVAL ENGINEERING.

Ventilating Apparatus.—The *Victoria* screw three-decker got up steam a few days since to test her machinery alongside Portsmouth dockyard, when an opportunity was taken to test the action of the ventilating apparatus on the plan invented by Dr. Edmouds, Staff-Surgeon of her Majesty's ship *Victory*, and which has been fitted on board by direction of the Admiralty under Dr. Edmond's supervision. It was ascertained by experiment that half a million cubic feet of the foulest air of the ship was constantly being carried off by its means through the funnel draught while the fires were lighted. With the fires unlighted about one-third the amount of air is carried off through the funnel. A ship once fitted on this plan, the apparatus remains self-acting, sucks the foul air out without creating draughts, and removes or prevents all endemic causes of disease in ships, particularly in tropical climates. The Admiralty have directed that several of her Majesty's ships are to be ventilated under Dr. Edmond's superintendence.

Trial of the "Royal Sovereign."—On the 1st ult. the *Royal Sovereign* turret ship, Capt. Sherard Osborn, C.B., started from Portsmouth for Portland on her first cruise since her conversion to a turret ship. On the following morning the anchor was weighed, and with three boilers out of her six, working at the lowest grade of expansion, the ship steamed through the Needles against a fresh breeze, making 5·4 knots. The same day she anchored in Portland Roads, and remained at anchor until the next morning, the interval being occupied in clearing up ship and setting matters straight. Steam was then got up in two boilers, the anchor weighed, and the *Royal Sovereign* steamed about the bay between the Portland Roads and Weymouth, her crew being exercised in bringing the ship to anchor and weighing again under different circumstances. During the night it blew very heavy from about S.W., and continued to do so throughout the following day. On the following morning steam was got up in four boilers, two-thirds power, and the ship was taken outside, and off the Race made a good eight knots against a strong wind and a heavy head sea. Captain Osborne then took the ship into the Race, and when fairly in the midst of the roughest water, put her broadside to it and let her roll and tumble about as she pleased, in order to test her turrets in as conclusive a manner as possible. The vessel rolled quickly 11 deg. to leeward and 10 deg. to windward, and under these circumstances the turrets and guns were manned, and the former revolved and the latter run in and out as would have been the case in action with an enemy in the same position and under the same conditions. It was found that the turrets were perfectly manageable, and the guns could be handled with the same ease as in smooth water, excepting, of course, that a little more care was required from the men in working them. The ship being still kept in her rolling position, the guns in the turrets were next trained nearly fore and aft, the winch handles let go and breaks slacked up, and turrets and guns left to themselves, the ship rolling in an arc of 21 deg. As, however, everything remained immovable, and it was found that the men could take hold of the winch handles and set the turret revolving, or leave them as they pleased, without leaving any check upon the turret's movement, this was deemed both by Capt. Osborn and Capt. Coles quite sufficiently conclusive of the turret's steadiness and working under as almost unfavourable conditions as could be met with, except in a gale of wind.

The Linnet, gunboat, 60 horse-power, after having been fitted with a condenser to her high-pressure engine, was on the 6th ult., taken to the measured mile off Maplin Sands, for trial. The vessel was under the command of Capt. W. K. Hall, C.B., and Mr. J. J. Greathead, chief engineer, and Mr. S. Townshend, foreman of steam factory in Her Majesty's dockyard at Sheerness, had charge of the machinery. The trial was conducted with results which are perfectly satisfactory, and are as follows:—True mean speed, 6·807 knots per hour; revolutions, 142 per minute; pressure of steam, 45lb.; vacuum, 27; load on safety valve, 60lb. The vessel went round the circle, with helm hard over at starboard, and two men at the wheel, in 1m. 50s.; the draught of water during the trial was forward, 7ft. 2in.; aft, 8ft. 2in.; the time under way and at full speed was four hours; the force of wind, 5; and the direction, N.W. The sea had a slight swell. The vessel was fully rigged and ready for sea, having 34 tons of coal on board.

Russian Iron-clads.—Two armour-cased frigates, built for the Russian navy by the Belgian firm of Cockerell and Co., have recently been launched. One of these, the *Vest-choune*, called a Monitor, was sent on a trial trip in the Baltic soon afterwards, and the result has been in every way satisfactory, as proving, according to the *Messeger de Cronstadt*, the vessel is equal to encounter any storms she may be likely to meet in the Baltic. The journal mentioned gives a detailed report of the cruise, from which we make the following extract:—The Monitor *Vest-choune*, accompanied by the steam vessel *Vladimir*, and hoisting the flag of Rear-Admiral Likhatchew, chief of the iron-clad squadron, left Cronstadt to August 3rd, and after touching at one or two ports entered Revel on the 5th, which place she left on the 8th at 8.30 a.m., and at 4 p.m. reached Helsingfors. In this trip she had to contend against a rough sea, which washed over the deck, and the waves even at times reached to the top of the turret. Notwithstanding this, the Monitor behaved admirably, and did not lessen her speed for one moment. Her engines worked well, as did also the isolating apparatus on which the compass rests, in order to protect the magnetic needle from the action of the iron, and to diminish its declination. This apparatus consists of a long copper tube, in the interior of which the compass is fixed with the mariner's card reversed, but reflected in a mirror. On the 11th the *Vest-choune*, still sailing in company with the *Vladimir*, again set sail, and on the 12th, after a short stoppage at Glasholm, they continued their cruise in the vicinity of that place. However, the wind having freshened, a heavy sea arose, and the waves were again thrown on the deck of the iron-clad. She rolled in a peculiar manner, quite different to that of other vessels; her oscillations described angles of 7½ and even 8 degrees. Notwithstanding this she steamed ahead quite well, and her engines continued to work in a most satisfactory manner.

The Confederate Iron-clad "Tennessee," which was recently captured in Mobile Harbour, was a fine steam propelled, iron-clad ram, 200ft. in length, and 48ft. 6in. in breadth. She carried 6in. and 7in. rifled guns. Her defences consisted of a wooden framework some 23in. thick in the aggregate, and covered with 5in., or over certain portions with 6in., of armour. This armour was composed of plates, or bars, of iron about 6in. in width, and varying in thickness from 2in. to 1in. Three layers of the thicker bars gave 6in. of ironworks; two of these and one of the thinner gave 5in. It is said that at

certain points of the greatest exposure the wooden hacking received an additional thickness, but in its strongest part of the armour of the *Tennessee* consisted of some 30in. of wood and 6in. of iron, and no more.

Steam Applied to Long Boats of the French Navy.—The French Government has adopted a very useful measure. It is decided that the long boats of the Imperial Navy shall henceforth be provided with steam engines. It has come to this resolution after experiments made in the presence of a naval officer, with a launch in the Seine, in the vicinity of Paris. It has already had four of this sort of vessels constructed. They are about 35ft. long, and have engines of fifteen and twenty horse-power. The boat which was experimented attained a speed of 7½ knots in descending the river, and 7 3-10ths, in ascending.

The "Orontes," screw troopship, 2,812 tons and 500 horse-power, made her official trial of speed on the 14th ult., at the measured mile in Stokes' Bay, preparatory to leaving England on troop service to the Cape and the Mauritius. The ship's draught of water was 22ft. 6in. aft, and 22ft. forward, with six months' stores and provisions on board, and 1,000 tons of coal in her hunkers. There was a strong wind from the south-west throughout the time the ship was under trial. Six runs were made with full boiler power, the mean of which gave the ship a mean speed of 10·882 knots, and the mean of two runs made with half boiler power gave her a speed of 8·721 knots. The maximum revolutions of the engines were 52, and the minimum 50. The load on the safety-valve was 12lb. The temperatures taken gave, on deck, 66 deg.; first run, engine-room, 70 deg.; ditto, forward stoke hole, 96 deg., 92 deg., and 80 deg.; sixth run, engine room, 72 deg.; ditto, forward stoke hole, 104 deg., 94 deg., and 82 deg.

The "Victoria," screw three-decker, fitted as the future flagship for the Admiral commanding her Majesty's fleets in the Mediterranean, on the 21st ult. made her steam reserve trial of speed at the measured mile in Stokes Bay, near Portsmouth. Six runs were made over the mile with full boiler power, and gave the ship a mean speed of 11·800 knots. Two runs with half boiler power gave her a mean speed of 9·290 knots. The mean revolutions of the engines were 58 at full power, and 48 at half-power. With full power the half circle was made in 3 min. 20 sec., and completed to the full circle in 6 min. 43 sec. With half power the half circle was made in 4 min., and the full circle in 8 min. 20 sec. As the *Victoria's* engines are 1,000 horse-power nominal, and as the ship drew but 23ft. 7in. forward and 25ft. 9in. aft, the speed attained at full power cannot be considered very great.

A New Species of Binnacle Lamp, the invention of Mr. C. W. Brown, an officer of the civil service in the Deptford Dockyard has been transferred to Woolwich, by order of the Lords of the Admiralty, to be inspected by Mr. Turner, the master shipwright, and the officials of the yard, and to be fitted on board Her Majesty's steam storeship *Industry*, on probation. The result of the inspection was as follows:—1. From the construction of the reservoir no overflow of oil can take place. 2. From the form of the reflector double the amount of light is given. 3. There is no downward shadow, and the illumination of the compass card is complete. The lamp is always perpendicular, so that there is no smoking or blackening of the sides of the lamp, as in the lamps now used. The lamp is shipped on the top of the binnacle. Bearings of any object can be taken by night with the greatest facility, the shade not being encumbered by the lamp, as the light is reflected down upon the compass card, and shows the latter clearly and distinctly. The lamp burns from ten to twelve hours with a moderate consumption of oil.

Naval Appointments.—The following appointments have taken place since our last:—H. J. Layland, Chief Engineer to the *Cumberland*, for the *Forte*; P. Richmond, of the *Royal Oak*, confirmed as Engineer; S. V. Bull, of the *Chanticleer*, confirmed as First-class Assist.-Engineer; Michael Harris of the *Insolent*, promoted to Acting Engineer; T. G. Woodfield, of the *Asia*, J. W. Owen, of the *Dasher*, H. Burstow, of the *Meanee*, R. B. Nicholson, and J. W. Watson, of the *Indus*, to be First-class Assist.-Engineers; G. Glasson, Chief Engineer, to the *Brisk*; H. J. Packer, Assist.-Engineer, to the *Brisk*; W. Fenton, (a), and H. Griffin, Assist.-Engineers, to the *Brisk*; J. Adams, Assist.-Engineer to the *Asia*, as Supernumerary to the *Victory*; James Carlisle, Acting Chief Engineer, to the *Fisgard*, as Supernumerary; William Giles, Engineer, to the *Fisgard*, as Supernumerary; George West, of the *Fisgard*, for the *Bustler*, and John W. Smith, Supernumerary of the *Fisgard*, confirmed as Engineers; John B. Grant, Assist.-Engineer, to the *Hector*; Henry Hall, Assist.-Engineer, to the *Brisk*; W. Nicholson, Assist.-Engineer, to the *Fisgard*, for hospital treatment; R. Stevens, of the *Royal George*, P. Baldwin, of the *Warrior*, Charles Ware, of the *Adventure*, G. B. Bissaker, of the *Marlborough*, H. R. Wills, of the *Sutlej*, and G. Haystay, Supernumerary of the *Asia*, promoted to be Engineers; and G. H. Newbury, of the *Firefly*, to be Acting-Engineer; J. Greathead, Chief Engineer, to the *Procis*, for service in Gibraltar yard; L. Backler, Assist.-Engineer, to the *Victoria and Albert*; H. T. Layland, Chief Engineer, to the *Cumberland*, for the *Mars*; H. Williams, Chief Engineer, to the *Cumberland*, for the *Forte*; T. H. Morgan, Engineer, to the *Asia*, as supernumerary; W. P. Guyer, Acting Engineer, to the *Indus*, for the *Espoir*; J. Barnett, of the *Fisgard*, W. H. Barker, of the *Indus*, and Henry J. Packer, of the *Frederick William*, confirmed as First-class Assist.-Engineers; W. Annan, Assist.-Engineer, to the *Indus*, as supernumerary; P. Foulis, Assist.-Engineer, to the *Pembroke*, for her tender; E. T. Peach, Engineer, and H. Vatcher, Second-class Assist.-Engineer, to the *Britannia*, for the *Dapper*; N. H. Rowe, Acting Second-class Assist.-Engineer, to the *Cumberland*, for the *Bristol*; W. M'Intyre, Acting Second-class Assist.-Engineer, to the *Cumberland*, for the *Terrible*; J. Leys, Chief Engineer, to the *Achilles*; H. C. Jones, Engineer, to the *Asia*, as supernumerary; W. H. Elliott, G. L. D. P. Keelin, and T. Richards, Engineers, to the *Achilles*; H. Hall, First-class Assist.-Engineer, to the *Indus*, as supernumerary; J. W. Watson, First-class Assist.-Engineer, additional, to the *Brisk*; E. Barrett, of the *Cumberland*, and F. E. Shean, of the *Jaseur*, confirmed as Second-class Assist.-Engineers; J. Watson (A), Assist.-Engineer, to the *Fisgard*, for the *Black Eagle*; J. Barnett, E. J. Murphy, R. H. Trubshaw, John Phillips, J. Phillips, J. Shore, and M. A. Fothergill, to the *Achilles*; J. Stanley, in the *Pandora*, promoted to Acting Engineer; G. Thomson and R. H. Cooper, in the *Cumberland*, promoted to First-class Assist.-Engineers; W. C. Graham, Second-class Assist.-Engineer, to the *Brisk*; F. J. Baron, Acting Second-class Assist.-Engineer, to the *Cumberland*. The following engineers, assistant-engineers, and engineer students connected with the Sheerness Steam Reserve have received second-class certificates of efficiency as the result of the first half-yearly examination, which was held in Sheerness Dockyard on the 13th, 14th, and 15th of June:—J. H. Brettell, Engineer, in the *Recruit*; J. B. James, Engineer, in the *Erne*; C. Chambers, Engineer, in the *Cumberland*; J. Bruce, Engineer, in the *Alacrity*; J. W. Hewitt, Engineer, in the *Horatio*; J. Marsh, Engineer, in the *Ætna*; J. Ellis, Engineer, in the *Linnet*; N. Farrant, Engineer, in the *Pigeon*; R. H. Trubshaw, First Assist.-Engineer, in the *Achilles*; W. Rumble, First Assist.-Engineer, in the *Wizard*; J. Robinson, First Assist.-Engineer, in the *Fearless*; C. D. Thomas, First Assist.-Engineer, in the *Spanker*; T. S. Flynn, Second Assist.-Engineer, in the *Cumberland*; J. H. Willes, Second Assist.-Engineer, in the *Cumberland*; J. Bruer (B) promoted to Chief Engineer; M. A. Fothergill, Second Assist.-Engineer, in the *Cumberland*; H. M'Evoy, Second Assist.-Engineer, in the *Cumberland*; W. H. Rowe, Second Assist.-Engineer, in the *Bristol*; G. T. Stronach, Second Assist.-Engineer, in the *Cumberland*; and R. Butler, R. Pearce, W. Oates, T. Middleton, W. Cooper, and H. Scott, Engineer students. The examination consisted of questions prepared on the following subjects by the Rev. J. Woolley, LL.D., one of her Majesty's Inspectors of Schools—viz., geography, English grammar and composition, French, arithmetic, algebra, geometry, trigonometry, statics, dynamics, hydrostatics, chemistry, and steam and the steam engine.

MILITARY ENGINEERING.

Breech-loading Rifles.—The Secretary of State for War is desirous of receiving communications from gunmakers and others on the subject of the best means of converting the Enfield rifle into a breech-loader, under the following conditions:—1. Cost not to exceed £1 per arm. 2. Shooting of the converted arm not to be inferior to the unaltered arm. Descriptions of methods proposed, accompanied by specimen arms, should be sent to the Director of Ordnance, War-office, Pall-mall. These descriptions and specimens will then be considered by the Ordnance Select Committee, who will select such of the plans as appear to them *prima facie* promising. Six rifles will be delivered for conversion to each of those gentlemen whose plans have been selected as above. They must be returned altered within five weeks of the date upon which they are sent, accompanied by 1,000 rounds of such ammunition (and to be ignited in such manner) as the competitors think most suitable. A sum of £20 will be paid to each of the selected competitors, to cover the expense of converting the six rifles and the supply of ammunition required.

STEAM SHIPPING.

Trial Course for Steamers in the Mersey.—The increase in the shipbuilding trade of Liverpool has rendered a defined course for the trial trips of steamers very desirable. Several have been buoyed out at sea, but in most cases the tide flows athwart the course, and thus renders very great the difficulty of obtaining accurately the speed. At the Mersey Dock and Harbour Board, held on the 8th ult., it was resolved on the motion of Mr. Laird, M.P., to have a mile course marked in the river, where the tide will flow with or dead against the vessel; and thus with the allowance for the force of the tide render the rate of speed more easily attainable.

Trial Trip of the "Foam."—This paddlewheel steamer, which, with her sister ships the *Petrel* and the *Scud*, has been bought for the China trade, was recently tried on the Thames, starting from Tilbury. She is not a new boat, but has undergone considerable alterations in the hull and machinery, and at the measured mile in Sea Reach she attained a mean speed of about 14½ knots an hour, with 250 tons of dead weight on board. The *Foam* was built by Messrs. Samuda Brothers, her engines, of 240 horse-power, being supplied by Messrs. Ravenhill, Salkeld, and Co. Her length is 230ft., and extreme breadth 26ft., or inside the bulwarks 24ft.

Steam Shipbuilding on the Clyde.—The Union Shipbuilding Company has launched from its yard at Kelvinhaugh an iron screw of the annexed dimensions:—Length, 130ft.; breadth, 21ft.; depth, 14ft. She was named the *Perthshire Lassie*, and is now being fitted with a pair of direct-acting engines of 40-horse power. Messrs. A. Stephen and Sons have launched from their Kelvinhaugh yard an iron screw of 450 tons, named the *Spartan*. This vessel has been built for Mr. R. Little, of Greenock, and is to be devoted to the intercolonial trade. An iron-clad frigate, built by Messrs. J. and G. Thomson, of Govan, for the Danish Government, has made a satisfactory trial trip. The frigate is of the annexed dimensions:—Length, 290ft.; breadth of beam, 50ft.; depth of hold, 30ft.; and burden, 3,200 tons. Her engines, which are built on the direct-acting horizontal principle, are 550-horse power. She is plated from stem to stern with armour-plates 4½in. thick. The plates are fixed to teakwork 19in. thick, and within the teak are the vessel's iron-plating and ribs, thus making her a most formidable ship. Her dead weight at present is fully 4,800 tons, with a draught of 16ft. 9in; but when she is fully equipped and furnished with 20 heavy guns on her lower deck and 16 guns on her upper deck her draught of water will be somewhat increased. At the trial trip, although the screw was not completely immersed, the frigate attained a speed of about twelve knots per hour. Messrs. Blackwood and Gordon, of Port Glasgow, have launched an iron tug named the *Flying Meteor*, built for the Clyde Shipping Company. The *Flying Meteor* is 115ft. in length, 18ft. 6in. beam, and 10ft. deep. Her engines, which will be put on board by her builders, are a pair of side levers of 120 horse-power. Messrs. Blackwood and Gordon have on hand for the same company two other steamers, one paddle and one screw; making ten vessels built by them for the same firm since 1860. Messrs. Caird and Co., of Greenock, are about to commence two new steamers for Messrs. Burns, to be devoted to the Belfast and Glasgow mail service. These vessels will be named the *Llama* and *Buffalo*, and will be ready by the spring of 1865. Messrs. Caird and Co. have also received an order from the North German Lloyd for a large screw, to be ready by the summer of 1865; this vessel will be built on the same plan and will be of the same dimensions and power as the *America*, now running on the line between Bremen, Southampton, and New York. Messrs. Caird have launched a large steamer named the *Stanley* for the London and North-Western Railway Company, intended to be employed by the directors between Holyhead and Dublin. The *Stanley* is of the following dimensions:—Length, 237ft.; breadth, 29ft.; depth, 15ft.; registered burden, 984 tons old measurement. She will be fitted with oscillating engines of 320 horse power, and is expected to attain a speed of upwards of 15 knots per hour. Messrs. A. and J. Inglis, of Point-house, have launched a paddle named the *Carham* for the North British Railway Company. The dimensions of the *Carham* are:—Length, 140ft.; breadth, 20ft.; depth, 8ft. 6in.; burden, 272 tons builders' measurement. She has been fitted by Messrs. Inglis with engines of 70 horse-power. Messrs. Randolph, Elder, and Co. have launched from their Fairfield yard a paddle of 847 tons builders' measurement, named the *Fingal*; she is the fifth paddle launched by Messrs. Randolph, Elder, and Co. in three months for a firm engaged in the Southern trade. Messrs. Aitken and Mansel, of Whiteinch, have launched a paddle of 1,180 tons, named the *Susan Beirne*, and a sister ship to the *Banshee*, which left the Clyde a week or two since. The *Susan Beirne* is built entirely of cast steel, and will be fitted with oscillating engines of 250 horse-power, by Messrs. James Aitken and Co., of Cranston-hill. Her principal dimensions are:—Length of keel and fore-rake, 250ft.; breadth, moulded, 31ft.; depth of hold, 11ft. 6in. Messrs. W. Denny and Brothers, of Dumbarton, have launched an iron screw, named the *Jupiter*, for the Austrian Lloyd's Steam Navigation Company. Her dimensions are:—Length, 264ft.; breadth, 34ft.; depth, 26ft.; burden, 1,615 tons builders' measurement. She is to be supplied with surface condensing engines by Messrs. Denny and Co., of 250 horse-power nominal. A paddle named the *Largs* has been launched by Messrs. T. Wingate and Co. for the Wemyss Bay Railway Company. The dimensions of the *Largs* are:—Length of keel and forerake, 160ft.; breadth of beam, 19ft.; ditto over paddle-boxes, 36ft.; depth of hold, 8ft.; gross burden, 285 tons; registered burden, 200 tons, builders' measurement. She is to be fitted with a pair of fore and aft diagonal engines, of about 100 horse-power, with feathering wheels, and she will carry two vertical cylindrical boilers. There is at present on the stocks in a forward state in Messrs. Wingate's yard a screw of 515 tons and 90 horse-power, for Messrs. Seligman and Co., of Glasgow, and intended for the Continental trade. There are also laid down two paddles for the West Indies, of 930 tons and 715 tons, and of 250 and 200 horse-power respectively. An iron screw of 1,000 tons, built and engined by Messrs. W. Simons and Co., has been launched from the London Works, Renfrew. This vessel is fitted with a pair of geared engines of 200 horse-power, and is intended for the mail service. She is named the *Principe Amedeo*, and has accommodation for 100 passengers; she has a steam windlass, a steam crane, and every recent improvement. A preliminary trial has been made of the engines of the *Moravian*, a screw built for Messrs. Allan's mail service. Mr. A. Denny, of Dumbarton, has launched a paddle named the *Maude Campbell*, intended for the Nassau trade, and exactly similar to several other steamers recently built in the neighbourhood. She is to be engined by Messrs. R. Napier and Sons, Glasgow.

Forty Miles an Hour at Sea.—A Liverpool paper observes that Mr. James Steel

a working joiner of that town, has invented a screw propeller, and that he states, from experiments made on the Prince's Park Lake, that with this screw he can get four times the speed of the ordinary screw with the same engine and the same pressure of steam. The screws are worked reverse by means of two wheels at the centre boxes of the screws, and can be replaced at sea at any time, and being only one-third in the water can be unshipped without any difficulty. There are six blades in one frame, the reversible one catching the backwater as the ordinary one, giving thereby five times the velocity, as proved the last three to four years on Prince's Park Lake. The steam on his model is raised by naptha. The Admiralty has been communicated with, and the Duke of Somerset has ordered the tracings to be sent, which was done on the 1st inst.

TRIAL TRIP OF THE "KNIGHT TEMPLAR."—On the 15th ult. the iron paddle-wheel steamship *Knight Templar*, forming one of the fleet belonging to the original Mersey Steam-tug Company, went on her trial trip. The *Knight Templar*, which was built by Messrs. W. C. Miller and Son, Toxteth Dock, is 130ft. in length, 11ft. in depth, and her tonnage, by builders' measurement, is 273 tons. The engines, which are a pair of 45 horse-power, are direct acting angle engines. The cylinders are 38in. in diameter, with a 4ft. 6in. stroke. The steam pressure was 30lb.; vacuum, 28; the indicated horse-power 6½ times the nominal power, a rather unusual circumstance; and the speed attained, 11 knots on the average. Run from Liverpool to Llandudno and back. With the ebb fully 12 knots were made.

TRIAL TRIP OF THE "LONDON" IRON SCREW STEAMSHIP of 1,700 tons burden, the first of a new commercial steam fleet owned and building by Money, Wigram, and Sons, of Blackwall-yard, took place on the 22nd ult, from Tilbury to the Nore lightship and back. This ship was launched about seven weeks ago, since which her masts and spars have been supplied, and her machinery fitted by Messrs. Humphrey and Tennant, of Deptford. The *London* is a fully-rigged clipper ship, her engines not exceeding 200 horse-power, and being intended rather as an auxiliary to aid the ship when becalmed or delayed by adverse winds than as a solely reliable motive power. Although not in good sailing trim upon the top of a flood tide she attained a speed of more than 11 knots with a singular freedom from vibration.

TRIAL OF A YACHT FOR THE SULTAN.—On the 19th ult. the trial trip of the *Izzeddin*, a yacht for the Sultan, took place at the measured mile on the Maplin Sands. This vessel has been built by the Thames Ironworks and Shipbuilding Company at Blackwall. She was designed by Mr. George M'Crow. the naval architect of the company. Her dimensions are—length, 250ft.; breadth, 29ft. 6in.; depth, 18ft.; and her burden, 1,076 tons. Her engines, manufactured by Messrs. John Penn and Son, are of 300 horse-power. The results were as follows:—1st run, 3 min. 27 sec., = 17·391 knots; 2nd run, 3 min. 47 sec., = 15·929 knots; 3rd run, 3 min. 36 sec., = 16·667 knots; and 4th run, 3 min. 33 sec., = 16·901 knots. The mean of the four runs was 16·722 knots per hour, which is equal to 19¼ statute miles. The vessel had 120 tons of coal on board. The indicated power was 2,264 horses; the revolutions 41, and the pressure of steam 26. The engines worked admirably.

A FAST BLOCKADE RUNNER.—Messrs. Jones, Quiggin, and Co., of Liverpool, have lately completed the *Colonel Lamb*, a steel paddlewheel steamship, of 1,788 tons old measurement. She has been built and fitted with engine power with a view to great speed as a blockade runner. On Tuesday she went on her trial trip, and took the opportunity of having a two hours' race with the Isle of Man steamer *Douglas*, the fastest boat yet known on the Mersey. In 2 hours and 31 minutes the *Colonel Lamb* beat the *Douglas* by about 4 miles. Her engines were constructed by Messrs. James Jack and Co., of the Victoria Engine Works, Sandon Dock. They are a pair of oscillating engines, of 350 horse-power, and have the advantage of the application of surface condensers, while the paddlewheels, which are on the feathering principle, are of 26ft. diameter. The coal used was Welsh steam coal; the pressure of steam, 40lb.; vacuum. 25; and the number of revolutions averaged 30 per minute. By log the ship ran 16¾ knots, or about 19 miles an hour.

LAUNCHES.

LAUNCH OF AN IRON-CLAD FOR THE TURKISH GOVERNMENT.—On the 2nd ult., Messrs. Robert Napier and Sons launched from their ship-building yard at Govan, the *Osman Ghazy* iron-clad, one of three in course of construction for the Turkish Government, the others being the *Abdul Aziz*, which is expected to be launched in January last, and the *Orkhan*, which will be ready about four months afterwards. The keel of the *Osman Ghazy* was laid in March, 1863. The ram is armour-plated from stem to stern, and of the following dimensions:—Length over all, 300ft.; extreme breadth, 56ft.; depth moulded, 37ft.; tonnage, o.m., 4,200; draught of water, 24ft. 9in. The stem of the vessel projects about 4ft. beyond the upper deck at the water line, and its strength is considerably increased by a centre line bulkhead extending backwards about 40ft., and which is supported by double angle iron, so as to strengthen it to resist the shock of collision with an opponent. For further security this longitudinal bulkhead is intercepted by transverse bulkheads, thoroughly watertight, and forming a series of distinct compartments the same as in other properly constructed iron vessels, only they are stronger, and there are more of them. The keel is formed in three separate pieces—namely, a web plate 4ft. deep, with two keel bars 12in. by 3in., rivetted on their lower edge, and to which the keel plates are attached. The framework of the vessel is in six pieces, intercepted by longitudinal girders, these girders being attached to the shell plating, and secured on their upper edges by longitudinal covering plates and bars inside. The vessel in construction is similar to that of the *Hector*, which was built by the same firm for the British navy. The armour-plates extend 6ft. below the water line at the middle of the ram, and are carried forward and aft, so as to extend 4½ft. below the water line at the bow and stern. The three lower streaks are about 8½ft. in depth above the armour shell, and are 5½in. thick, tapering forward to 5in., and aft under the counter to 3in. From this to the upper deck they are 5in. thick, tapering forward and aft to 4½in. The plates are pierced by portholes 2ft. above the main deck. The portholes are 3ft. 6in. in height, and 2ft. in breadth, so as to allow the guns of the main deck being worked easily. There are two magazines, and every precaution has been taken to place them as much as possible beyond the reach of the enemy's shot and shell. The vessel has four decks, including the upper or spar one. She will be propelled by horizontal direct-acting engines of 900 horse-power nominal, which will be supplied with steam from six boilers. Her armament, as at present arranged, will consist of 24 guns, though provision has been made for 38. Twenty of these will be 68-pounders, and the remaining four, which are to be placed on the upper deck, being 110-pounders. The bow guns are to be protected by a strong shield thrown forward on the upper deck, formed of 4in. armour plates. The vessel is to be bark-rigged, and the lower masts and the lower and topsail yards are to be made of iron.

RAILWAYS.

IRISH RAILWAYS.—In Ireland there were, on the 31st of December, 1863, 1,741 miles of railways open; 238,794 trains ran, of which 203,977 were passenger trains, carrying 11,462,191 passengers, which, taking the population at 6,000,000, gives nearly two journeys for each person. There were three accidents, by which twenty-one persons were injured, but no one was killed. The receipts from passenger traffic were £942,279; from goods traffic, £576,375; and from all sources, £1,518,654. The gross working expenditure was 49 per cent., and amounted to £750,412, leaving net receipts £768,242. The Irish lines yielded in 1863 net receipts giving £441 5*s*. 3*d*. for each mile open; the Scotch lines, £898 0*s*. 5*d*. per mile; while the English railways realised £1,572 9*s*. 6*d*. per mile.

THE RAILWAY CLEARING-HOUSE.—The clearing-house, being so essential to the railways, has naturally kept pace with their multiplication. In 1845, three years after its first establishment, the number of companies on its books was only 16; ten years later it had risen to 73, and it is now 110, with a united mileage of 10,859 miles. In reality the number of companies does not give an adequate notion of the growth of business, in consequence of the leasing and amalgamations which are always going on. The clearing-house knows only the companies which actually work the lines, and deals only with the interchanged traffic, without touching that which is confined to the line of any particular company. A brief summary of what the clearing-house accomplishes at the present time will give a fair idea of the important part which it plays in the railway system. The number of stations sending traffic returns monthly is as follows:—Goods and cattle, 3,121; passengers, 1,817; parcels, 2,368. The number of pairs of stations between which bookings are carried on monthly is:—Goods and cattle, 62,470; passengers, 15,145; parcels, 16,626. Each of these passengers, each of these cattle or packages, has to be traced throughout its whole journey, and a statement drawn up of the distance which he or it has travelled over each division of the route. The average number of railways over which each consignment of goods is conveyed is 3·08; each passenger, 3·46; each parcel, 3·07. The gross receipts for twelve months amount to an aggregate of £8,044,791, as compared with £401,651 in 1845, and £4,829,649 in 1855. The present total is thus composed:—Goods and cattle, £5,937,753; passengers, £1,805,915; parcels, £301,123. The total amount of the receipts of traffic of all kinds cleared in this office since its establishment reaches the enormous sum of upwards of £81,000,000. Not only each passenger and consignment, but each carriage, waggon, and tarpaulin has to be traced through the mass of returns from the thousands of stations up and down the country. The total amount for mileage and demurrage comes to £287,937.

RAILWAYS IN INDIA.—There are at present ten railways in India either opened for a portion of their whole distance or in process of construction, and some of these have branch lines. Two lines, the Scinde (114 miles) and the Eastern Bengal (115 miles), are finished their whole length. The total length of line now opened for traffic is 2,687¾ miles, and 2,100 miles yet remain to be constructed before the system, as far as sanctioned, will be completed. Since the first of January, 1863, 358½ miles have been finished and opened up to January last. Last year, 279 ships carried out from this country 106,850 tons of goods, valued at £1,285,464, for the railways, while nearly a like quantity was sent during the previous twelve months. The shipments of railway materials to India from this country have altogether amounted to 2,764,781 tons, of the value of £5,126,856. Most of the servants of the companies are at present Europeans, of whom there are now 2,800; but it is thought that in process of time the natives may be brought to discharge many of the duties, which will tend greatly to facilitate the more economical working of the line.

ACCIDENT ON THE LONDON, CHATHAM, AND DOVER RAILWAY.—An accident, unattended with fatal consequences, occurred on the 26th ult., at an early hour to the down morning express fast train on the London, Chatham, and Dover Railway. This train left Victoria and Blackfriars stations at 7.30 a.m., and having amalgamated at Herne Hill proceeded on its journey for Dover. After passing through the Sydenham-hill tunnel the train ran by Penge station, and was travelling over the slight embankment about a quarter of a mile beyond this spot when, from some unexplained cause, the engine left the rails, and after running for 200 yards over the sleepers and permanent way, fell upon its side down the embankment, dragging with it a second-class carriage. The passengers in the first-class carriages, of whom there were about 30, escaped injury (these carriages not having left the line). The driver and stoker stuck to their posts and were both slightly hurt.

RAILWAY ACCIDENTS.

ACCIDENT ON THE LONDON AND NORTH-WESTERN.—An accident occurred at the London and North-Western Company's station, Birmingham, on the night of the 5th ult. The 6 o'clock express from London due at 9 p.m., arrived punctually. The engine had passed through the tunnel on to the line in the station; at this point the engine, tender, and guard's van, with one passenger carriage, passed on all right. The second and third carriages were thrown off the rails, and the fourth carriage was thrown on to its side. In it fortunately there were only two passengers, who escaped without being much hurt. They were extricated through the windows on the upper side. The remaining portion of the train, consisting of three or four first and second-class carriages, with the last guard's van, remained on the rails. The train having been brought to a stand the carriage thrown on its side was dragged along a few yards, and ultimately the end of it came in contact with a portion of the platform, which it tore up. A part of one large flagstone, three feet in length, was forced into the carriage which had been thrown over. The passengers above referred to were extricated, having sustained no very serious injuries.

RAILWAY COLLISION AT ALTRINCHAM.—On the 7th ult. a special train of London and North-Western carriages was despatched from Manchester at 10 o'clock in the morning to Knutsford with passengers to the Agricultural Show. The train reached Altrincham in safety, and part of it was there backed upon a siding in order that three other carriages might be added. The train was an exceedingly long and heavy one, being filled with passengers. In the act of backing the train the engine accidentally got detached, and the driver lost the power which he would otherwise have had of checking the momentum which his engine had previously given to the carriages. The consequence was that, the siding being on a slight incline, and the rails being what is called "greasy," from a slight shower of rain having fallen upon them, the train fell back faster than was intended against the three carriages intended to be attached, carrying these back in their turn against the stop blocks. To a looker-on the train moved back so gently that it would have been thought no injury could have resulted, and many passengers in the carriages experienced no sensible shock; but this was not the case with passengers seated nearer the rear of the train. Not being held back by the engine in front, each carriage as it fell back upon the one behind increased the momentum of the train, and the shock upon the hindmost carriages, so soon as they met with obstruction in the rear, was so great as to throw many of the passengers from their seats, severely hurting several.

RAILWAY COLLISION NEAR WIGAN.—On the morning of the 11th ult. a railway collision occurred on a spot which has attained an unenviable notoriety as the scene of so many railway accidents, the junction of the Springs Branch Coal Railway with the North Union line, about a mile south of the Wigan station. About 20 minutes past 9 on the 11th ult. a train of 32 waggons laden with iron ore was backed on to the Spring Branch from the main line. The branch at this point is rather steep, and the engine-driver in a few moments found he had not force enough to send his waggons up the hill, and he therefore ran down the branch to the level again for a fresh start. He crossed the facing point, and had proceeded a few yards along the down line when a long and heavily laden luggage train from London to the North, drawn by two powerful engines, was noticed approaching on the same line. The luggage train was moving at the rate of 20 to 25 miles an hour, and, as the mineral waggons were also running at a moderate speed, it was seen to be impossible to prevent a collision, and engine-drivers and stokers jumped to the ground, and escaped without injury. About a score of yards from the facing points the two trains met, and in a few seconds the line presented such a scene of havoc as is rarely witnessed. The engine attached to the mineral waggons and the first on the luggage train were of course hopelessly smashed, the massive iron work being bent and broken as if the engines had been a couple of match boxes; but the second luggage engine was not so much in-

jured, the chief damage being to the buffers and some of the plating at the front. Two of the waggons of the mineral train were broken, and at least a dozen of the luggage trucks were more or less damaged, five being completely destroyed, and their contents scattered in confused heaps upon the line.

Railway Collision.—On the afternoon of the 14th ult., a railway collision happened to the train out of Stafford for Wolverhampton at 1.50. When the train, which was well filled, and consisted of about seven carriages, arrived near the Bushbury junction, which it was to pass, it came into collision with a coal train, and a serious shock was the result. A large number of the passengers were slightly injured.

BOILER EXPLOSIONS.

Boiler Explosion.—On the 7th ult., a boiler attached to Wheal Uuy whim-engine suddenly exploded, blowing out both ends, and causing the death of the engineman and injury to two others. It appears that the outer case of the boiler has been under repair, and was again being set to work when the accident occurred. The opinion of the engineer is that the boiler must have leaked, and the feed having got beyond its proper level, caused the accident. The working of the engine is not interrupted, the other boilers being uninjured.

Boiler Explosion near Glasgow.—On the afternoon of the 9th ult., a boiler explosion, causing serious loss of life and personal injury, occurred at the print works of Messrs. J. and A. Conbrough, Strathblane, about twelve miles distant from Glasgow. The boiler which gave way was one of the ordinary cylindrical shape, measuring 24ft. in length by about 8ft. in diameter, and had only been in use about eighteen months. The accident occurred in the afternoon, when the works were in full operation; the first intimation of the occurrence being a loud report. Then followed the noise of falling masonry, while the vicinity of the boiler became enveloped in clouds of steam, and inundated with streams of boiling water. One of the inside flues of the boiler had given way, and the force of the explosion had blown off the furnace door, which was projected with great force against a dye-house immediately opposite the boiler. The wall of this building was blown down, and the exploded mass traversed the whole length of the interior, knocking down the wall at the opposite end, while a considerable portion of the roof was carried away. When the walls gave way the interior of the dye-house was exposed to a deluge of scalding water mixed with steam, occasioning injuries which in several cases afterwards proved fatal, in addition to those who were hurt by the falling materials.

DOCKS, HARBOURS, BRIDGES, &c.

New Pier at St. Ives.—The foundation stone of a new pier has been laid at St. Ives. It is intended that the pier shall extend 615ft. in a south-easterly direction, running into a depth of water of 30ft. at high-water, and 6ft. at low-water mark spring tides. The pier will consist of two parts,—a sea-wall next the shore, 191ft. in length, formed wholly of stone, and a breakwater similar to that now being constructed at Falmouth, consisting of timber frames filled with rubble stone. The end of the pier will be round, and of strong basket-work of timber, also filled with stone, the foundation of which will be 60ft. in diameter and 10ft. 6in. in depth, constructed of brickwork with concrete hearting.

Lambeth Bridge.—The directors reported to the shareholders that the balance in hand applicable to a dividend was £1,819 3s. 10*d*., and they recommended a dividend at the rate of 8 per cent. per annum for six months ending the 31st day of August, 1864, to be payable on the 30th ult. This left about £580 to be carried to the next account. The recommendation was agreed to.

Devonport and Keyham Dock Accommodation.—By the report of the select committee on dock accommodation at Devonport and Keyham, it appears that some of the witnesses think that two additional first-class docks are required there; others think three. The south basin, 7 acres 32 perches, has, during the last year, been deepened 6ft.; it is now 25ft. deep, but it can be deepened by pumping to 28ft. The north basin, 5 acres, is being enlarged in a northerly direction to, say, 10 acres. The side of the northern boundary-wall next the basin has been finished with wrought stone, water-tight: the side to the north, distant 60ft., is faced with the rough stone from the buildings of the old gunpowder magazine. There is some discussion about the possibility of placing one dock inside the other, as in some of the Russian arsenals, by which mode the level of the platform of the inner dock is considerably higher than that of the outer. Then there is a difference of opinion as to whether the dock should run north and south, parallel with the Hamoaze, or at right angles with that harbour, like those already constructed inside the basins both at Devonport and Keyham.

Messrs. Tod and M'Gregor's New Slip Dock.—In the year 1856 the firm of Messrs. Tod and M'Gregor purchased about 14 acres of ground for the purpose of forming, graving, and other repairing docks, the want of which had been long felt. Such accommodation was urgently called for by shipowners and others interested in the welfare of the *Clyde*, as at that time the only accommodation of this sort in the harbour was afforded by two slip docks capable of taking on vessels of 800 tons, and one for vessels of 300 tons. These gentlemen had no sooner made purchase of the ground than they put it into the hands of their engineers, and within fifteen months of this period they possessed a fine graving dock, with tidal basin, quays, and wharves, steam and power cranes of the largest size, premises fitted with steam hammers and tools of every description, and everything else requisite to form a dockyard capable of repairing and fitting out the largest vessels afloat. It is good evidence of the foresight of the late members of this firm that, within so short a period of their deaths, the present firm found the necessity to provide further accommodation, absolutely necessary to go on with the extension of this scheme by the formation of one of the slip docks. The working plans were prepared in the spring of the present year, and the work let in May last, which is now actively progressing towards completion. The slipway is 557ft. in length, and will be capable of taking on a vessel of 800 tons. The foundation of the slipways is formed of four rows of piles from the top of the slip down to the extreme end of it, and a portion of these piles will be driven and cut off under water. The upper portion of the ways is formed of timbers laid upon beams of whole logs set across the entire breadth of the slip over the bearing piles, the spaces under the ways between these cross bearers being filled with concrete made of gravel and hydraulic lime, forming a foundation of the most solid description. Upon these ways four lines of massive cast iron rails are laid. The lower part of the slip is formed of an immense raft or platform of timber 210ft. in length, formed of sleepers of whole logs bound together with diagonals and runners, strongly bolted and trussed to this framing. Upon this a continuation of the ways and rails is formed. This platform will be built upon the shore, launched into the river, floated into its place, and adjusted by means of guide piles and other appliances, then sunk upon the piled bed prepared for it by ballasting it with stones, the spaces between the piles having previously been filled in with sand and gravel, properly levelled off. This will then form a complete line of rails from head to foot of the slip, laid to a uniform inclination of 1ft. perpendicular to 18ft. horizontal. Upon these rails the cradle travels upon which the ship is set, and hauled up the slip. Wharves of stone and timber are constructed on each side of the slip, from which the ships are set, steadied, and adjusted on the cradle. The hauling power consists of Miller's hydraulic purchase, a most massive apparatus, which hauls up the cradle by direct action, without intervention of wheels or machinery. The pumps which work the purchase are driven by a steam-engine. The line of rail which is about to be formed through Partick in connection with the Edinburgh and Glasgow Railway goes directly past the end of the slip, and a siding will be formed into the dockyard, by which means coal, timber, and iron will be brought into the premises.

Holborn Valley Improvement.—The following are the provisions of the Act for authorising the corporation to raise the Holborn valley:—The Act provides for a viaduct, or high-level street or road, commencing at or near Ely-court, Holborn-hill, and terminating in Skinner-street, at or near the Old Bailey; also for a new street commencing at or near the junction of Hatton-garden with Holborn-hill, and terminating in the Farringdon-road at a place in that road nearly opposite the spot where the intended new line of street from the Metropolitan Meat-market will join Farringdon-road, near the present junction of West-street with Farringdon-road; also a street commencing at or near St. Sepulchre's Church, and on the northern side of Skinner-street, and terminating in Farringdon-road, about 50 yards to the north of Snow-hill; also the widening of Shoe-lane, and the carrying of that lane up to and so as to form a junction with the roadway of the viaduct. Moreover, the western side of that part of Farringdon-road situated between Holborn-hill and the junction of the first-named new street is to be widened, and the levels of Farringdon-street and Farringdon-road to be altered, commencing at or near Newcastle-street and terminating about 230ft. north of New Charles-street, beyond the Metropolitan Railway station. Snow-hill, Field-lane, and Great Saffron-hill, between Holborn-hill and Charles-street, to be stopped up and otherwise appropriated, as also will be the present roadway of Skinner-street and Holborn-hill and the southern end of King-street and Ely-place. If the "Mayor, Aldermen, and Commons" do not purchase the property scheduled within five years after the passing of the Act, their compulsory powers to make such purchase to cease. Should the viaduct, or raised way, and new lines of street be not completed within five years—namely, by 1869, the powers given by "The Holborn Valley Improvement Act, 1864," to the corporation, "shall cease to be exercised" by that body, "except as to so much thereof as may then be completed."

Hutchesontown Bridge.—The bridge across the Clyde at Hutchesontown, Glasgow, having become insecure, in consequence of the foundations having been undermined by the deepening operations of the river, it has been unanimously resolved by the Glasgow Bridge Trustees to take it down and build a new one; and, accordingly, Messrs. Bell and Miller, M.I.C.E., have been instructed to prepare the necessary plans. The new bridge will be about 400ft. in length and 60ft. wide, in three spans. The arches will be of iron, and the piers granite.

Milford Haven.—The almost unequalled natural advantages of this harbour are at last about to be turned into some practical account, and, as a first step in that direction the foundation-stone of the Hubberston Docks has been laid, and the works are already in progress. The new Milford Docks, are also to be commenced without delay, and there is every probability that the Newton Noyes Ocean Pier will be carried out as well. A line of railway is being promoted to Fishguard and Cardigan, which will place the port in direct communication with the great narrow gauge systems of the country, and it is not improbable that cotton may ultimately be shipped largely at Milford. Should these undertakings be vigorously proceeded with, and carried out in their integrity—and there is no reason to think otherwise—there cannot be a doubt that Milford will in a few more years become one of the chief ports of South Wales.

MINES, METALLURGY, &c.

Coal in China.—The *China Mail* describes some coal pits being about five miles north from Kubshaukan up a steep ravine or woody opening in the main valley, the path to them rough and stony in the extreme. There are about fifteen shafts open, each of their entrances being enlarged into a room where the colliers sleep and eat at times, though more comfortable dwellings have been built for overseers and contractors. We engaged a miner to show us down the largest shaft, which measured on the average only 4½ft. high by 5ft. wide. It is cased with willow sticks in a secure manner, and the roof is particularly well guarded. The bottom is lined with the same to form a ladder up and down which the miners travel in their daily labour. This shaft is about 150ft. deep and the ladder down to the digging is perhaps 600ft. long. The coal is secured on small wooden sledges, and drawn as the miner slowly crawls up along the narrow and slippery step by a strap passing over his forehead, each load weighing 80 catties. One workman brings up six loads as his day's work. The sides of this shaft showed the widths of the veins of coal, but the top and bottom were not dug out. At the bottom the shaft divided and led towards two deposits, but neither passage had been dug out. The whole was very dry, owing, probably, to its elevation up the hill, but some shafts have been abandoned from wet and bad air, and their mouths closed. The labourers are hired out by contractors, who sell the coal to the dealers coming from Pekin and elsewhere. It is all carried away on the backs of camels or mules, and it is a painful sight to see the unwieldy camels coming down the rocky, uneven road bringing their loads of coal. It is delivered in Pekin at about three piculs for a dollar, and a large part of the price is for carriage. The coal is hard, but such examination as the time afforded disclosed not a vestige of stump or leaf to compare with the fossils of other coal regions. More careful research will doubtless bring to light some indications of this kind, enabling scientific men to compare the numerous deposits of soft and hard coal in this part of China with the European coal measures.

Quicksilver—How to Test it and Detect Adulteration.—Quicksilver, after being extracted by the plain process of retorting, is seldom quite pure, and generally contains a small proportion of other metals. The eminent naturalist Priestly suggests a very simple method to purify mercury, by merely shaking it strongly in an iron flask, and renewing the air in the same repeatedly with a pair of bellows. By this manipulation a black powder will be formed on the surface, which can easily be separated. If no more of this dust is formed the quicksilver may be considered pure. In this state it will always give a clear sound when agitated in the flask, while an admixture of lead will make it sound dull, as if the vessel were made of potter's clay. It is often found in the market wilfully adulterated with lead, tin, and bismuth. Of lead, it can absorb or dissolve almost one-half of its weight, without losing much of its limpidity. This adulteration can easily be discovered by rubbing some of the metal on the open palm; if it soils the skin it is adulterated—if pure it leaves no trace. Besides, if dosed with lead, it will leave a tail behind—"*il fait la queue*," to use a French expression—that is, the drops, instead of being globular, will assume an elongated form, and a more or less flattened surface. Some of these observations may be, perhaps, useful to the gold miner, as many complaints have latterly been heard about the impurity of the quicksilver sold in the mines, which fact is also proved by the frequent occurrence and admixture of base metal in the amalgam gold, probably, in most cases, by artificial means.

Extraction of Auriferous Silver out of Ores in the Liquid Way.—When ores contain alloys of gold and silver, the ordinary modes of extraction in the liquid way give very unsatisfactory results, the yield being always too low. Even the hyposulphites, of which such excellent use is made in extracting silver, leave a considerable portion of the gold undissolved. It is found necessary to apply first Augustin's or Ziervogel's methods to extract the silver, and then Plattner's method to obtain the gold, or the converse; but in every case both gold and silver remain in the residue, and it is necessary to repeat the operation, or to concentrate the residue by smelting. The explanation of this is, that none of the solvents used hitherto are capable of dissolving simultaneously the gold and silver, and there is always formed on the surface of the alloy a film insoluble in the agent employed. For instance, if chlorine water be used part of the gold is dissolved, but by the formation of insoluble chloride of silver a limit to the action is soon reached, and if then the chloride of silver is dissolved in ammonia, common salt, or a hyposulphite, there is soon formed a coating of metallic gold, which protects from action the interior parts of

the alloy. The agent proposed for overcoming those difficulties is simply a concentrated solution of common salt saturated with chlorine. The ore is simply roasted and lixiviated with this solvent, which takes out all the gold and silver.

ACCIDENTS TO MINES, MACHINERY, &c.

COLLIERY EXPLOSION NEAR SHIELDS.—An explosion took place on the night of the 8th ult. in Seghill colliery, about eight miles from Shields. The colliery is situated in the heart of the steam coalfield and has extensive workings. About 11 o'clock the night shiftmen were down the pit, and eighteen hewers and timber leaders and rolley lads were employed at the workings in a remote part of the pit known as Far California, when the gas appears to have fired at some of their lights, the explosion tearing down the main rolley way, but meeting with a volume of fresh air at the cross cut it expended itself there without doing any more serious mischief. The pitmen employed felt the shock of the explosion in other parts of the pit and flocked to the bottom of the shaft, where they were got to bank in a short time in safety. The explosion has taken place in the Low Seam. The men were mostly employed in the "broken," and that part of the colliery where the explosion took place was considered somewhat fiery. The air was close in the early part of the night, and afterwards there were high winds. Eleven men and boys were got safely out of the pit, the remainder being killed.

GAS SUPPLY

HARTLEPOOL GAS AND WATER COMPANY.—At the annual meeting of this company, the plans and specifications for the erection of the new reservoirs at Hart, for the supply of the two towns with soft water, were laid on the table, and they showed that the two reservoirs would cover an extent of sixteen acres, and would be capable of holding 20,000,000 gallons of water. A dividend of 6½ per cent. was declared, free of income-tax.

THE MALVERN LINK GAS COMPANY have declared a dividend of 5 per cent. for the last half-year, carrying over £150 2*s.* 5*d.* to the credit of the company.

CARBONISATION OF ILLUMINATING GAS.—The advantages resulting to gas consumers from the carburisation of the gas supplied by the companies has now become generally recognised, and the apparatus for effecting the thorough mixture of the benzole or naphtha vapour with the gas has now been so simplified, that whatever objections may formerly have existed have been entirely removed, so that it may be hoped Dr. Knapp's observation, as to the discovery being of benefit to individuals only, will no longer apply. Referring to naphthalised gas (and it may here be mentioned that the carburisation is always effected with mineral naphtha, benzole, or some other material not widely different from them), Dr. Knapp, in his well-known "Technology," observed that "the illuminating power of gas is very much increased by the presence of volatile hydrocarbons, and many years ago Mr. Lowe introduced, or rather proposed, a plan for saturating inferior qualities, or ordinary coal gas, with naphtha, or the spirit distilled from coal-tar, and thus augmenting its illuminating power nearly one-half. The remarkable increase of light, however, produced by naphthalised gas frightened the gas companies, who foresaw nothing but ruin in the diminished quantity of gas which would necessarily be consumed for the production of an equal amount of light. Cold water was consequently thrown upon the project, and the invention has only been of benefit to individuals, and not to the public at large, which might have been the case had it been introduced upon a large scale." Since this opinion was expressed other inventors have been more successful than Mr. Lowe, and there is no reason why the benefits of a rich, pure, and economical light should not be generally diffused. We have examined the improved carboniser, known as Woodward's Patent Gas Improver and Carboniser, and the results produced are certainly all that could be desired. In this apparatus the gas is made to pass over the surface of benzole or mineral naphtha, receiving its vapour and obtaining a vastly increased illuminating power. It is claimed that in passing over the surface of the fluid the gas comes into contact only with the amount necessary for its purification, so that the vitality of the spirit is retained until it is all consumed. Dr. Muspratt has reported very favourably upon the invention, and photometric experiments have proved that, taking gas at 4*s.* 6*d.* per 1,000 cubic feet, there is a saving of more than one-third, the same amount of light being obtained for 2*s.* 11*d.* The apparatus is at present in use in some hundred manufactories, printing offices, &c., and a large number of testimonials of its efficiency have been obtained.

THE LENOIR GAS ENGINE, "STEAM SUPERSEDED."—The Lenoir engine is in appearance and style very much like a horizontal steam-engine, having a cylinder, piston, crank-shaft, and fly-wheel. The cylinder has the necessary slide arrangements for the admission of the gas (the ordinary city coal-gas, supplied from the service-pipes) and atmospheric air, in due proportions: the gas is ignited at the proper moment by the electric spark from a battery connected by wires to each end of the cylinder—the connection being made and detached by the rotary action of the crank-shaft. The expansive force consequent on the ignition gives motion to the piston on each side alternately. The cylinder has a water-jacket surrounding it, through which a stream of water is kept gradually flowing, to keep it cool. The engine, once fixed, the battery charged, and the gas turned on, it is ready for action at any desired moment, needing no engineer to superintend its working; and as soon as the work required of it is completed, and the gas shut off, the engine instantly stops, and the expense ceases. The daily cost of gas and chemicals is trifling, and there is no boiler and no chimney. It can be worked on any floor of a house, and almost under any circumstances.

THE MANCHESTER CORPORATION have resolved to reduce the price of gas, within the city, from 3*s.* 6*d.* to 3*s.* 2*d.*, large consumers paying a trifle less, and consumers beyond the city a higher rate. A profit of nearly £60,000 was made last year, and of this sum about £28,000 will be devoted to improvement purposes.

THE WEST HAM GAS COMPANY have declared a dividend of 4 per cent. for the six months ending 30th June last, in addition to ½ per cent. to make up for deposit dividends previously paid by the company. The report states that, during the past six months, three millions of cubic feet of gas had been consumed more than in the corresponding period in 1863. The new offices are now nearly completed.

THE SHERBORNE GAS COMPANY.—The annual meeting of this company has been held for the first time in the company's own building. Although the report shows a profit of £468, and a 7½ dividend absorbed only £300, the report is not so favourable as last year. The balance of profit and loss, however, was so large last year, that £1,000 were transferred to capital account, new shares to that amount being distributed among the proprietors. The usual dividend of 7½ per cent. was declared on both old and new shares, and a balance of nearly £100 will then be carried over. The company are laying down a new main, and have announced a reduction in the price of gas from 6*s.* 3*d.* to 5*s.* 10*d.* per 1,000, with a discount of 10*d.* per 1,000 off for cash.

THE HANLEY GAS CONSUMERS' COMPANY (LIMITED) are making progress towards the establishment of gas works.

WATER SUPPLY.

THE FYLDE WATERWORKS COMPANY have a capital of £60,000. The water is got from Grizedale fell, and is collected in a reservoir at Nickey Nook, a ravine which has been dammed up for the purpose. This dam or embankment is nearly completed. It is upwards of 70ft. high, and 370ft. wide at the base, and 12ft. wide at the top. It encloses a reservoir of fifteen statute acres surface area, and capable of storing 100 millions of gallons of water, which passes by 12in. pipes to Weeton, where there is a circular service reservoir 408ft. in diameter at the base, and 468ft. at the top, with an embankment 70ft. in diameter at the base and 12ft. at the top. It is formed on the summit of a hill, the excavation being used in the circular embankment, and will hold about 15 million gallons.

STALYBRIDGE WATERWORKS.—At a special meeting of the Stalybridge town council, it has been determined to apply to the Poor-Law Board for an order, under the authority of the Public Works Act, for a loan of £65,000, to be made to the corporation, for carrying out the Ashton and Stalybridge Waterworks Act of 1864.

THE SOWERBY BRIDGE WATERWORKS, HALIFAX, have been opened. These works have been laid out by the local Board of Health, at the cost of about £6,000.

CROYDON WATER SUPPLY.—Recently a series of testings have taken place at the new well, Mr. Doewra, the contractor, having completed the undertaking, the depth of the boring being 150ft. It has been ascertained that a continual supply of water, amounting to about 840,000 gallons, can be obtained in the space of twenty-four hours, and this without in any way interfering with the yielding of the old well, from which, at the same time, one million gallons and a half per day can be supplied.

APPLIED CHEMISTRY.

MANUFACTURE OF CHLORINE.—Many means have been employed for the manufacture of chlorine, including the application of the bichloride of copper and other bichlorides, but hitherto without success. Mr. De Tregomain has patented an invention which relates to improvements in the manufacture of chlorine by means of bichlorides, and also to the method of revivifying the latter. After the bichloride, which is heated to a deep red, has disengaged about half its chlorine, and has changed to a state of protochloride, he collects it, while in a state of fusion, and pours it on marble slabs, and then grinds it in a mill. The powder he obtains is introduced into a revivifying apparatus, in which he passes a current of air of sufficient amount, when the protochloride in powder, in coming in contact with the oxygen of the air, becomes changed into oxychloride, or mixture of binoxide and bichloride of copper. In order to effect the revivification, he places the powdered oxychloride in stoneware vessels, containing hydrochloric acid at 23° Beaumé, in the proportion of about 1 cwt. of dry oxychloride to 100lbs. of acid. The matters are then heated, cooled, and crystallised, and the mother waters drawn off, the crystals being dried and distilled over again.

ALUMINIUM.—A new method for obtaining this metal at a very small cost has just been discovered, says *Galignani*, by M. Corbelli. He takes a certain quantity of pure clay, say 100 grammes, and dissolves it in six times its weight of concentrated sulphuric, nitric, or hydrochloric acid. The solution is then allowed to stand, and afterwards decanted. The residue is first dried, and then heated to 450 or 500 degrees centigrade; after which it is mixed with 200 grammes of prussiate of potash, which may be increased or diminished according to the quantity of silica contained in the clay. To this mixture 150 grammes of common salt are added. The whole is then put into a crucible and heated until the mixture becomes white; when cool, a button of pure aluminium is found at the bottom of the crucible.

A NEW QUADRUPLE SALT, BY M. PELTZER.—By treating sulphate or acetate of copper by hyposulphite of soda there results, as is well known, a double sulphite, which has been studied by M. Lenz and M. Rammelsberg. This hyposulphite is soluble in ammonia, to which it imparts a blue colour, and when left to itself the solution deposits a mass of blue crystals which constitute the new salt. It may be obtained still more easily in the following manner:—Divide into two equal parts a mixture of sulphate of copper; supersaturate one with ammonia and the other with hyposulphite of soda, and mix the two solutions; by shaking the mixture, the new product is deposited in a crystalline mass of a beautiful violet colour. The latter gives out a decided ammoniacal odour, especially if reduced to powder; it will bear a temperature of 100° C. Heated in a tube it loses no water, but forms a white sublimate which becomes orange by cooling. When boiled with water this sublimate emits ammonia, and on the addition of hydrochloric acid there follows a disengagement of sulphurous gas, which shows the sublimated product to contain M. H. Rose's sulphate—ammon. Mixed with chlorate of potash, it detonates with some violence. Water, especially when hot, decomposes but does not dissolve it; a green matter and white flakes of a salt of protoxide of copper are formed, and ammonia is disengaged; by prolonged boiling sulphide of copper is formed. The new salt is soluble in ammonia, hyposulphite of soda, and acetic acid. Heated with potash it deposits at the boiling point a mixture formed of protoxide and deutoxide of copper. The solar rays decompose the acetic solution, hypochlorite of soda also destroys it, forming a white precipitate containing protoxide of copper and tetrathionic acid. Nitrate of silver produces a white precipitate; the precipitate, however, soon disappears to give place to a green deposit soluble in ammonia, but easily giving a deposit of sulphide of silver. The deposit contains copper, silver, and hyposulphurous acid. The author is of opinion that iron, zinc, and silver may be substituted for copper; besides, ferruginous sulphate of copper gives a quadruple salt containing iron. The author has found for the percentage composition of this salt—

$Cu_3\,O_2$	27·76
NaO	15·52
NH_3	8·52
$S_2\,O_2$	48·19

thence he deduces the formula—

$$S_2\,O_2\,Cu_2\,O,\ S_2\,O_2\,Cu\,O + 2\,(S_2\,O_2\,Na\,O) + 2\,Az\,H_3.$$

According to him ammonia here plays only a passive part, acting in the same way as water of crystallisation.

SODA IN COAL GAS.—On examining the flame of the gas supplied in Munich, Professor Vogel remarked a pale soda line which was not observed when the gas was passed through sulphuric acid. On analysing afterwards the deposit on the surface of a copper burner which had been in use a year, the Professor found a considerable proportion of sulphate of soda.

ANILINE.—Dr. Albert Kremer, of Stettin, bases his process of manufacturing aniline upon the fact that the nitrobenzoyle is easily reduced by zinc powder and water, in heating it. Zinc powder, which is produced in the manufacture of zinc, contains from 85 to 90 per cent. of this metal, and its price is about 3*s.* per cwt. less than raw zinc. The aniline is prepared in a retort connected with one cooler turned up and one turned downwards. A trial pipe, turned downwards and furnished with a pet cock, is fitted to the connecting pipe, which allows of examining, from time to time, the substances returning from the cooler turned upwards to the retort. From 2 to 2½ parts of zinc powder, 5 parts of water, and 1 part of nitrobenzoyle, are first distilled at a very soft fire, and eventually 100 parts of nitrobenzoyle will yield from 63 to 65 parts of aniline, which possesses the purity of the aniline supplied by the trade, without requiring a preliminary rectification. This process takes place according to the following formula:—

$$C_{12}\,H_5\,NO_4 + 6Zn + 2HO = 6ZnO + C_{12}\,H_7\,N.$$

ANILINE IN VARNISHES.—When an alcoholic solution of aniline is evaporated upon a glass plate, there remains a thin transparent coating of aniline, which by reflected light appears as a metallic green iridescence, but by transmitted light of a blue or violet colour, according to the shade of aniline used. As aniline is soluble also in spirit varnishes, it is proposed to prepare such a blue transparent varnish for coating bottles, used for the preparation of substances easily affected by light.

LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT, OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF THE ARTIZAN."

DATED AUGUST 26th, 1864.

2104 R. Hill—Iron and steel
2105 C. G. Lundborg—Extracting oils from coal, or other bituminous substances
2106 H. Hathaway—Paper, cardboard, and other similar substances
2107 M. L. Muller—Watches
2108 J. Strouse—Shirts
2109 W. Allen—Covering certain descriptions of rollers
2110 E. Hunt—Planing wood
2111 H. Jackson—Tentering or stretching and drying fabrics
2112 R. Marshall—Carriage windows
2113 G. Haseltine—Manufacture of boots and shoes

DATED AUGUST 27th, 1864.

2114 E. Calvert—Preparing and spinning fibrous materials
2115 James Niven—Grave monuments
2116 P. A. Le Comte de Fontainemoreau—Artificial Stone
2117 E. John—Bedsteads

DATED AUGUST 29th, 1864.

2118 J. Campbell—Floating docks
2119 J. Cheetham—Self-acting mules for spinning cotton
2120 W. Rowden—Sails
2121 F. W. Armitage—Cutting or working coal or other minerals
2122 R. W. Thomas—Apparatus for taking photographic pictures
2123 R. A. Brooman—Signalling apparatus, specially applicable to signalling on board ship
2124 R. A. Brooman—A new thread, and the manufacture therefrom of fabrics and ornaments
2125—R. A. Brooman—Hair pins

DATED AUGUST 30th, 1864.

2126 J. Jones—Coating iron with steel
2127 J. Packer—Signals in railway trains
2128 C. Russell—Manufacture of bricks by improved machinery
2129 J. Shanks—Water closets
2130 W. Clark—Railway apparatus for the better prevention of collisions
2131 H. H. Henson—Sheathing or protecting ships or vessels
2132 A. Smith—Machinery for applying paste and other liquid adhesive material
2133 C. W. Harrison—Looms for weaving
2134 G. Wilton—Communication between passengers, and between passengers and guards on railways

DATED AUGUST 31st, 1864.

2135 W. Bullough—Looms
2136 A. E. Peirce—Troughs, racks, and enclosures for cattle
2137 J. Stenhouse—Rendering certain substances less liable to decay
2138 W. C. S. Percy—Washing or scrubbing shop fronts, windows, watering gardens, and similar purposes
2139 J Baptiste Andreux & E. Coulon—Combination of steam and air as a motive power to vessels of all descriptions
2140 A. F. Fontaine—Disconnecting apparatus, by means of which machinery can be promptly stopped
2141 Sir J. Macneill—Railway signals
2142 G. Furness—Caissons employed in constructing embankments and other walls, and other like structures
2143 A. Rollason—Glazing and varnishing pictures and photographs

DATED SEPTEMBER 1st, 1864.

2144 E. Petito—Breech-loading fire-arms
2145 T. Wilson—Breech-loading fire-arms
2146 J. White—Lifeboats
2147 J. H. Johnson—Apparatus for sounding alarm or signal bells
2148 W. Clark—Registering apparatus applied to vehicles
2149 H. Hennison—Rotary steam and water power engines
2150 T. Fowler—Coating pins, &c., with tin or other metal
2151 J. S. Guy—Enabling passengers travelling by railway trains to communicate with the guard and driver

DATED SEPTEMBER 2nd, 1864.

2152 E. M. Water—Improved gas valve and regulator
2153 J. H. Wilson—Breech-loading cannon
2154 J. T. Hewes—Wind engines
2155 N. Stubber—Application of the screw and worm and screw and pinion wheel, or endless screw and wheel, for propelling cars, carriages, and all description of land conveyances, and multiplying the power of steam, water, atmospheric, and all other motive power engines and machinery.
2156 J. F. P. Hugouenq—Obtaining indigo from textile materials
2157 W. L. Duncan—Bleaching rags, and rag engines for paper making
2158 A. M. J. Comut de Molin—Electro magnetic engine
2159 P. M. Parsons—Ordnance and projectiles
2160 M. Burland—Obtaining motive power, and in applying the same to the propulsion of ships or vessels
2161 R. A. Brooman—Making the joints of metal pipes tight
2162 W. W. Burdon—Getting coal, and in apparatus employed therein

DATED SEPTEMBER 3rd, 1864.

2163 J. Ivers—Flyers employed in roving and spinning cotton
2164 C. W. Standish—Boiling eggs
2165 J. Barber—Watching and signalling throughout railway trains
2166 D. Greenfield—Screw eyes for holding stair rods

DATED SEPTEMBER 5th, 1864.

2167 W. Langham—Construction of vessels of war and fortifications
2168 T. E. Symonds—Construction of ships and other vessels
2169 A. V. Newton—Machinery for manufacturing nails
2170 E. R. Lloyd and S. Lloyd—Securing tubes in tube sheets
2171 E. R. Lloyd and S. Lloyd—Expanding tubes in tube sheets

DATED SEPTEMBER 6th, 1864.

2172 R. Shortrede—Fastenings for bales of cotton or other substances
2173 M. A. F. Mennons—Construction of sewing machines
2174 F. Weaver—Latches for doors, and other similar purposes
2175 J. K. Leather—Salts of chromium from chrome ore
2176 S. Corbett and W. Corbett—Agricultural implements
2177 D. Walker—Malting
2178 T. H. Baker & T. Woodroffe—Filtering water and other liquids
2179 J. Smith—Saving ships or other vessels from sinking
2180 A. Sharp—Cabinet bedsteads
2181 W. H. Perkin—Preparing colouring matters for dyeing
2182 W. J. Curtis—Railway carriages, and in the means to be employed by passengers in signalling to the guard

DATED SEPTEMBER 7th, 1864.

2183 J. Bullough—Roving intermediate slubbing frames
2184 W. H. Ward—Tramway and coach
2185 E. Burgess—Watch protector
2186 A. Smith—Ornamenting papier maché while in a soft state
2187 W. A. Hunter—Machinery for reaping and mowing
2188 W. Clark—Construction of the frames of umbrellas

DATED SEPTEMBER 8th, 1864.

2189 A. Moe—Construction of double-action submerged force pumps
2190 P. E. Placet - Engraving
2191 R. D. Chatterton—Coupling apparatus
2192 J. T. Crosland—Steam engines for forcing air or water
2193 J. Fleming—Extracting juice from the tobacco leaf
2194 T. Taylor—Urinals
2195 G. Bedson—Rolling wire rods
2196 A. V. Newton—Sewing machinery, parts of which are applicable to ornamenting fabrics, and covering buttons
5197 D. Fruwirth—Cutting photographic impressions

DATED SEPTEMBER 9th, 1864.

2198 H. Grafton—Cutting wood
2199 T. Wilson—Breech-loading fire-arms and ordnance
2200 W. Clark—Damping paper used in copying letters
2201 J. Sborrock, R. Sborrock, and W. Mould—Looms for weaving
2202 A. Wallis and W. Drewett—Threshing and dressing machines
2203 H. D. P. Cunningham - Running rigging and in working the same
2204 H. C. Lobnitz—Steam engines, and in the valve motion thereof
2205 T. Restell—Umbrellas
2206 W. Coppin—Construction of ships
2207 P. W. Barlow—Railways and tunnels

DATED SEPTEMBER 10th, 1864.

2208 J. Shepherd—Manufacture of wadding and waterproof fabrics
2209 P. A. Le Comte de Fontaine Moreau—Boots and shoes
2210 Sir J. S. Lillie—Propelling by atmospheric pressure
2211 C. J. Newbolt—Fixed and portable combined thrashing machines
2212 L. F. Goodbody—Mills for the manufacture of flour
2213 D. Brodie—Heating water by means of waste steam
2214 T. D. Ridley—Apparatus for mixing materials for making concrete
2215 J. Holding—Improvements in looms for weaving
2216 M. Fitzgerald—Signal communication between passenger and guard
2217 H. W. Cook—Telegraphs
2218 A. A. Davis—Communication between passengers and guard
2219 C. Moriarty—Preventing the escape of sparks from engines
2220 A. Watt—Facilitating the removal of the ends of eggs
2221 E. O. Potter—Cutting files

DATED SEPTEMBER 12th, 1864.

2222 J. Williams—Cleansing or tunning vessels or vats
2223 H. C. Baildon—Manufacture of inks or writing fluids
2224 R. Schleicher—Needles
2225 D. C. Knab—Obtaining motive power from steam
2226 G. Clark—Guns, gun carriages, and projectiles
2227 C. Sanderson—Ordnance
2228 A. G. Grant—Clock-work magnesium lamp
2229 R. F. Fairlie—Artificial fuel

DATED SEPTEMBER 13th, 1864.

2230 H. Potter—Bleaching fibrous substances
2231 J. Dean—Sea governors for marine engines
2232 E. Higham & R. Kirk—Knitting healds
2233 A. Belhomme—Preparation of jute
2234 J. M. Fisher—Roasting jacks
2235 A. C. Kirk—Ice
2236 J. H. Ritchie—Ships
2237 Z. S. Durfee—Apparatus for generating gas for fuel
2238 S. J. Taylor—Manufacture of hollow iron ware

DATED SEPTEMBER 14th, 1864.

2239 B. Glover—Carriage wheels
2240 P. Skeldon—Anti-friction bearings for shafts or axles
2241 J. Banks—Mules for spinning
2242 F. L. de Prebois—Syphon with a closing apparatus
2243 J. L. McLay & W. H. Thompson—Instruments for taking observations at sea during the night
2244 J. H. Johnson—Colouring matters obtained from aniline
2245 T. R. Hammond—Transportation of packages by instantaneous or graduated speed

DATED SEPTEMBER 15th, 1864.

2246 G. Haseltine—Boots and shoes
2247 J. E. Morris—Measuring distances passed over by pedestrians
2248 R. Townsend—Lubricator for cylinders of steam engines
2249 L. J. Paine—Advertising
2350 W. Chubb & S. Fry—Communication between passengers and engine drivers
2251 A. A. Wever—Machinery for washing yarns
2252 A. V. Newton—Preventing incrustation in steam boilers
2253 A. M. Perkins—Ovens
2254 A. Bertsch—Conductors for preventing atmospheric electricity damaging electric telegraph instruments
2255 R. T. Hall—Communication between passengers and guards in railway trains
2256 M. L. J. Lavater—Tubes of vulcanised india rubber

DATED SEPTEMBER 16th, 1864.

2257 T. Moy—Propelling trains
2258 J. G. Hey—Lubricating the axles of carriages
2259 J. R. Cafferata—Gasaliera
2260 J. H. Simpson—Printing by electricity for telegraphic and other purposes
2261 J. C. Hunter—Bookslides
2262 S. A. Baron—Bed-table
2263 S. A. Baron—Bedstead
2264 R. Holt—Hoods for ventilators
2265 F. Thornton—Arrangements for propelling vessels
2266 S. Bennett—Lubricators
2267 J. B. Huntington—Scales of aneroid and mercurial barometers
2268 W. Austin—Card board
2269 C. Attwood—Blast furnaces
2270 T. R. Crampton—Drying bricks, cement, and other articles
2271 J. B. Wood—Floor cloths
2272 C. Colombe—Mechanism for producing a continuous rotary motion

DATED SEPTEMBER 17th, 1864.

2273 C. Stephens—Forcing-up water
2274 C. Brown—Cutting open newspapers folded or otherwise
2275 M. D. Jeffreys—Railway turn-tables
2276 J. H. Johnson—Artificial fuel
2277 R. Chrimes—Hydrants or fire-cocks
2278 F. Yates—Iron and steel
2279 D. H. Brandon—Treatment of tar oils for the purpose of employing the same as paint
2280 J. Adams—Signalling between different parts of railway trains
2281 J. Harrison—Cleansing ships' bottoms
2282 J. H. Burns—Distillation of volatile minerals, and other organic matters
2283 R. Richards—Carriage axles
2284 W. Lea—Alarum, applicable to doors, windows, and otherwise
2285 E. Slaughter & F. L. F. Catliet—Locomotive engines
2286 D. Tamet—Obtaining light for light pipes and cigars
2287—J. M. Napier—Cleansing the lower parts of boots and shoes
2288 J. Smith—Machinery for spinning and winding wool

DATED SEPTEMBER 19th, 1864.

2289 A. Figge—Construction of safety match and and fusee boxes
2290 F. Tolhausen—Lighting shop fronts and other kindred purposes
2291 F. Tolhausen—Projecting the shuttle of a loom through the shed
2292 J. Vero—Brooms
2293 T. Taylorson—Apparatus for working coal or other minerals
2294 R. A. Brooman—Phosphuret of iron and alkaline phosphates
2295 R. W. Sievier—Wheels, and arranging them on their axles
2296 R. Flude—Weaving ribbons and other narrow fabrics

DATED SEPTEMBER 20th, 1864.

2297 C. F. M. Jessen—Treating and preparing silk waste or pierced cocoons
2298 W. Lawrence—Mashing and cooling worts and other liquids
2299 M. A. F. Mennons—Aerial navigation
2300 J. B. Schott—Envelope frame for the use of photographers
2301 A. Higgins—Embroidering or ornamenting spun fabrics
2302 S. Bates—Manufacture of lace and in the machinery employed
2303 C. H. Robinson, J. Fryer, and A. Dyson—Gins for cleaning cotton
2304 W. P. Struve—Manufacture of slabs or blocks of malleable iron
2305 W. Clark—Permanent way of railways
2306 W. Wilkinson—Yarns applicable for weaving into fabrics
2307 C. W. Howell—Communication between passengers and guards
2308 R. A. Brooman—Breech-loading fire-arms
2309 H. Rogers—Skates
2310 E. Smith—Wet gas meters

DATED SEPTEMBER 21st, 1864.

2311 L. Cooke—Paper cloth
2312 F. Hovenden—Railway signals
2313 I. Baggs & W. Simpson—Manufacture of chlorine
2314 J. L. Courcier—Lubricating
2315 E. T. Hughes—Fan to be employed for ventilation
2316 G. Scott—Salt cake
2317 R. A. Brooman—Manufacture of sugar and in the apparatus employed
2318 T. A. Rocbussen—Construction of furnaces for melting
2319 J. H. Johnson—Machinery for the manufacture of cigars
2320 E. Young—Application of fire-resisting materials

DATED SEPTEMBER 23nd, 1864.

2321 J. R. Hoffman—Disconnecting lever to release instantly any carriage or vehicle when the horses fall or run away
2322 J. H. Walsh—Breech loading fire-arms
2323 S. Laing—Cutting or shearing metal or other material
2324 F. L. M. Dorvault—Preventing fire-arms from getting greasy
2325 G. G. Bossey—Manufacture and fixing of studs and buttons
2326 H. Potter—Bleaching
2327 I. Watts—Burners for lamps
2328 J. Clark—Axle boxes, and the means of operating the same
2329 T. Walker & T. F. Walker—Utilisation of sewage matters
2330 G. Lister—Fire-arms
2331 E. R. Handcock—Engines to be worked by steam or other motive power
2332 W. Larcom—Protecting the bottoms and sides of ships
2333 P. Barr—Machinery for moulding pipes
2334 J. Rhodes—Adapting and applying pneumatic injectors

DATED SEPTEMBER 23rd, 1864.

2335 B. W. A. Sleigh—Continuous rotary motion by means of a hydrostatic rotatory motive power engine
2336 M. Henry—Dyeing and tanning, and in preparing for dyeing
2337 H. Vale—Eye protectors
2338 W. B. Woodbury—Producing by the aid of photography surfaces in relievo upon metallic or other suitable materials
2339 W. Palmer—Candles
2340 J. H. H. Kidd & J. C. Mather—Manufacture of floor cloth
2341 A. V. Newton—Machinery for manufacturing telegraphic cables
2342 A. H. Braudon—Refining petroleum and other oils

DATED SEPTEMBER 24th, 1864.

2343 J. Todd—Machinery for rolling plates and sheets of metal
2344 H. Bridgewater—Mode of manufacturing railway crossings
2345 W. Carter—Construction and arrangement of frames employed in the dressing of lace or other fabrics
2346 D. Climie—Life boats
2347 A. H. P. S. Wortley & W. W. Vernon—Photographic pictures
2348 R. A. Brooman—Raising liquid from a natural or artificial fall of liquid
2349 W. Greener—Breech-loading arms
2350 W. Arthur—Compasses for registering the course steered by a vessel
2351 W. Whittle—Machinery for the manufacture of nails
2352 J. T. Stroud—Materials used in representing the glass parts of chandeliers
2353 R. Hattersley—Warming apparatus

DATED SEPTEMBER 26th, 1864.

2354 G. P. Wheeler & F. Gloyn—Polishing metals
2355 P. A. Lecomte de Fontainemoreau—Cutting files
2356 E. Ostler—Brushing hair
2357 W. Scott—Casting iron pipes
2358 J. Fergus—Setting the sails of ships
2359 L. Alexander and W. B. Nation—Separating pitch from matters containing them
2360 J. A. Harrison—Applying to useful purposes the slag or scoria of blast furnaces


MERSEY DOCKS
AND
HARBOUR
BY J. J. BIRCKEL.
Fig 1.
Fig 2.
Fig 3
ROCK LIGHT HOUSE
WARRINGTON
VERTICAL SCALE
HORIZONTAL SCALE FIG 2 & 3
LIVERPOOL
HARRINGTON DOCKS
ROCK FERRY
DINGLE
DEVILS BANK
OTTERS POOL
ST MARYS CHURCH
NORTH OFFING BANK
GARSTON SANDS
Channel for Coasting Craft
for Flats
GARSTON
LIGHT HOUSE
L & N W RY
LIVERPOOL & GARSTON
COUNTY PALATINE OF LANCASTER
MAGAZINE COTTAGES
EASTHAM
EASTHAM FERRY
EASTHAM SANDS
SOUTH OFFING BANK
West Channel
OGLET BANK
DUNGEON POINT
DUNGEON BANK
RIVER MERSEY
HALE CHURCH
LIGHTHOUSE
HALE HEAD
DECOY
DITTON BROOK
WIDNES MARSH
ST HELENS CANAL
RUNCORN SANDS
Runcorn & Latchford Canal
ASTMOOR
DUKE OF BRIDGEWATERS CANAL
BRIDGEWATER DOCKS
RUNCORN
L & N W RAILWAY
LIGHT HOUSE
WESTON POINT
WEAVER CANAL
RIVER WEAVER
SCORE BANK
INCE BANKS
EMBANKMENT
INCE MARSHES
INCE HALL
STANLOW BANKS
ELLESMERE PORT
HOOTON HALL
RIVER GOWY
COUNTY OF CHESTER
SCALE OF CHAINS
SCALE OF YARDS

tion with the special tidal functions appertaining to the different regions, and these may be summed up as in the schedule annexed :—

"Schedule.

Distinguishing No. of Subdivision with its Area of Tideway.	Depths.			Sectional Areas.		
	Increased.	Unchanged.	Decreased.	Increased.	Unchanged.	Decreased.
	No.	No.	No.	No.	No.	No.
1st. 1,700 acres ...	9	2	1	8	...	4
2nd. 1,500 " ...	11	4	6	6	1	4
3rd. 15,800 " ...	11	4	13	8	...	6
4th. 3,000 " ...	7	4	9	1	2	8
5th. 450 " ...	8	2	4	3	...	3

"The results as here associated point to the following conclusions:—1st. An increase of capacity in those regions concerned in the admission and discharge of the tidal water,—a result the more important as evidencing a process which, if continued, may hereafter compensate for the artificial abstractions which have been made from the same areas. The general direction of the flood and ebb stream within this space prevails as recorded in "Giles's Survey," the curve being somewhat straightened—an alteration due apparently to the Liverpool Dock walls, which confine the current more to the fairway than formerly; and if so, these enclosure walls themselves may be found to contribute to the compensating process. In the absence of data as to the rate of current in 1819–22, there is no means of judging how that effect may have been varied by the restriction of the channel; the greatest velocity of current is now found at the stricture of Seacombe Point, where a series of observations have been made in mid-channel on the 16th April, 1862, during a high spring tide rising 20ft. 3in. above the old Dock Sill datum, the results of which are embodied in the table annexed :—

Table of Rates of a Tide observed off Seacombe Point, 16th April, 1862.

Flood.				Ebb.			
Time from Low Water.	Rate per Hour in Miles Nautical.	Time from Low Water.	Rate per Hour in Miles Nautical.	Time from High Water.	Rate per Hour in Miles Nautical.	Time from High Water.	Rate per Hour in Miles Nautical.
h. m.		h. m.		h. m.		h. m.	
0 30	1·1	4 30	3·7	0 30	1·2	4 30	2·6
1 0	2·0	5 0	1·1	1 0	4·5	5 0	2·4
1 30	4·0	5 15	Slack tide	1 30	6·3	5 30	2·3
2 0	5·3	...	...	2 0	6·3	6 0	1·7
2 30	6·0	...	...	2 30	5·7	6 30	1·1
3 0	6·3	...	...	3 0	5·5	7 0	0·6
3 30	5·7	...	...	3 30	4·3	7 25	Slack tide
4 0	4·0	...	...	4 0	3·9	...	...

"The second region claims further attention, as comprehending the area of Pluckington bank, and although the increase in tidal capacity is here less in degree than in the first instance, it is such as to prove conclusively a removal of deposit from this district.

"In the third region, the relations of depth at first sight appear to imply change adverse to the tidal flow; but the persistent characteristic of that portion standing under heading 'unchanged,' entitles it to be considered with the first in estimating the progress of the opposite tendency, and on reference to the relations of sectional areas, the appearance is reversed. The numerical results, as here quoted, so nearly approaching an apparent balance, illustrate the notorious vagrancy of the navigable channels, the changes in which are, beyond doubt, effected by great transpositions of matter.

"In the next regions, the sign of decrease of depth is again apparent, and with the condition shown in the sectional areas, undoubted evidence of accumulation is afforded; in these, however, it is easy to distinguish some features, the natural tendency of which is towards this result. First, in region No. 5. Here the utmost duration of the flood stream at spring tides is three-quarters of an hour, and at low neaps it is scarcely entered by the tide; consequently, only a small proportion of the tidal wave passes into it at any time, while the prevailing direction of its stream, with but short interruption at spring tides, is continually urging into the next area below the deposits derived from the drainage of the upper districts, until they are encountered by the tidal flow. Secondly, considered as the tidal breakwater, region No. 4, experiences modified effects corresponding to the cumulative process arising from operations similar to that of the sea drift upon ordinary sea beaches, and in this sense every transposition or disturbance of matter may be expected to contribute something to the accumulation; again, a large portion, probably two-thirds of this region, is only affected by the tide, within a short time of high water, when the disturbing effect of the current has ceased, and that of deposit most rapidly does take place; thus considered, it is almost entirely a receptacle for deposit.

"An interesting illustration of the opposing influences to which this region is subject, is found in the fact, that within its area the ordinary influence of spring tides is reversed, and that the lowest levels at low water occur at neap and not at spring tides; the bed of the river is here two or three feet above the highest low water level observed at Liverpool, and, as a consequence, the later portion of the ebb is independent of the general tidal levels, but maintains a higher, or recedes to a lower level, in proportion to the greater or less quantity of tidal water received from the flood tide and to be discharged during the ebb tide.

"The combined results of the several comparisons which have been reviewed, claim for the date of 1861 increased depth and capacity extending over an area of 19,000 acres, and a decrease over 3,000 acres, establishing a condition which in view of the maintenance of the scour necessary to preserve or promote depth in the sea channels must appear satisfactory. Whether the relations of increase and decrease as now established, are pursuing a persistent ratio, or whether they are peculiar to the era of which we have treated, cannot be precisely determined. Some natural causes applying to former ages, as well as to the present time, have just been mentioned; and it is open to question how far these have been mitigated or promoted by artificial means. The improved capacity of the tidal entry may be attributed upon well-known general principles to the more direct action of the tidal stream, which, however, will assist not only in promoting the ebb scour, but on the flood would exaggerate that effect which has been compared to sea drift. Again, with regard to the back-water formerly derived from the tidal area of marsh lands, although the level of these lands is for the most part such that the tidal flow reached them only for three or four tides in succession; yet the loss of such back-water implies the abstraction of an occasional power sufficient to re-transpose matter which otherwise is suffered to consolidate. In these two points, the former of which does belong to the era under consideration will be recognised peculiarities favourable to an increase in the modern ratio of accumulation as compared with that of former times; and it is obvious, therefore, that the satisfactory conditions now established are not unmixed with adverse tendencies. It was in reference to these tendencies that the natural and artificial shores were separately considered, and it seems worthy of consideration whether any means may be found

for procuring a further diminution of them, by extending the characteristic of permanency to the present base line of the cliffs or by permanently fixing the marsh edges."

(*To be continued.*)

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Meeting at Bath, 1864.

THE PRESIDENT'S ADDRESS.

Gentlemen of the British Association,—The place where we have been invited this year to hold our Thirty-fourth Meeting is one of no ordinary interest to the cultivators of physical science. It might have been selected by my fellow-labourers in geology as a central point of observation, from which, by short excursions to the east and west, they might examine those rocks which constitute, on the one side, the more modern, and on the other the more ancient records of the past, while around them and at their feet lie monuments of the middle period of the earth's history. But there are other sites in England which might successfully compete with Bath as good surveying stations for the geologist. What renders Bath a peculiar point of attraction to the student of natural phenomena is its thermal and mineral waters, to the sanatory powers of which the city has owed its origin and celebrity. The great volume and high temperature of these waters render them not only unique in our island, but perhaps without a parallel in the rest of Europe, when we duly take into account their distance from the nearest region of violent earthquakes or of active or extinct volcanos. The spot where they issue, as we learn from the researches of the historian and antiquary, was lonely and desert when the Romans first landed in this island, but in a few years it was converted into one of the chief cities of the newly-conquered province. On the site of the hot springs was a large morass from which clouds of white vapour rose into the air; and there first was the spacious bath-room built, in a highly ornamental style of architecture, and decorated with columns, pilasters, and tessellated pavements. By its side was erected a splendid temple dedicated to Minerva, of which some statues and altars with their inscriptions, and ornate pillars are still to be seen in the Museum of this place. To these edifices the quarters of the garrison, and in the course of time the dwellings of new settlers, were added; and they were all encircled by a massive wall, the solid foundations of which still remain.

A dense mass of soil and rubbish, from 10ft. to 20ft. thick, now separates the level on which the present city stands from the level of the ancient Aquæ Solis of the Romans. Digging through this mass of heterogenous materials, coins and coffins of the Saxon period have been found; and lower down, beginning at the depth of from 12ft. to 15ft. from the surface, coins have been disinterred of Imperial Rome, bearing dates from the reign of Claudius to that of Maximus in the fifth century. Beneath the whole are occasionally seen tessellated pavements still retaining their bright colours, one of which, on the site of the Mineral-water Hospital, is still carefully preserved, affording us an opportunity of gauging the difference of level of ancient and modern Bath.

On the slopes and summits of the picturesque hills in the neighbourhood rose many a Roman villa, to trace the boundaries of which, and to bring to light the treasures of art concealed in them, are tasks which have of late years amply rewarded the researches of Mr. Scarth and other learned antiquaries. No wonder that on this favourable spot we should meet with so many memorials of former greatness, when we reflect on the length of time during which the imperial troops and rich colonists of a highly civilised people sojourned here, having held undisturbed possession of the country for as many years as have elapsed from the first discovery of America to our own times.

One of our former Presidents, Dr. Daubeny, has remarked that nearly all the most celebrated hot springs of Europe, such as those of Aix-la-Chapelle, Baden-Baden, Naples, Auvergne, and the Pyrenees, have not declined in temperature since the days of the Romans; for many of them still retain as great a heat as is tolerable to the human body, and yet when employed by the ancients they do not seem to have required to be first cooled down by artificial means. This uniformity of temperature, maintained in some places for more than 2,000 years, together with the constancy in the volume of the water, which never varies with the seasons, as in ordinary springs, the identity also of the mineral ingredients which, century after century, are held by each spring in solution, are striking facts, and they tempt us irresistibly to speculate on the deep subterranean sources both of the heat and mineral matter. How long has this uniformity prevailed? Are the springs really ancient in reference to the earth's history, or, like the course of the present rivers and the actual shape of our hills and valleys, are they only of high antiquity when contrasted with the brief space of human anuals? May they not be like Vesuvius and Etna, which, although they have been adding to their flanks, in the course of the last 2,000 years many a stream of lava and shower of ashes, were still mountains very much the same as they now are in height and dimensions from the earliest times to which we can trace back their existence? Yet although their foundations are tens of thousands of years old, they were laid at an era when the Mediterranean was already inhabited by the same species of marine shells as those with which it is now peopled; so that these volcanos must be regarded as things of yesterday in the geological calendar.

Notwithstanding the general persistency in character of mineral waters and hot springs ever since they were first known to us, we find on inquiry that some few of them, even in historical times, have been subject to great changes. These have happened during earthquakes which have been violent enough to disturb the subterranean drainage and alter the shape of the fissures up which the waters ascend. Thus during the great earthquake at Lisbon in 1755, the temperature of the spring called La Source de la Reine at Bagnères de Luchon, in the Pyrenees, was suddenly raised as much as 75° F., or changed from a cold spring to one of 122° F., a heat which it has since retained. It is also recorded that the hot springs at Bagnères de Bigorre, in the same mountain-chain, became suddenly cold during a great earthquake which, in 1660, threw down several houses in that town.

It has been ascertained that the hot springs of the Pyrenees, the Alps, and many other regions are situated in lines along which the rocks have been rent, and usually where they have been displaced or "faulted." Similar dislocations in the solid crust of the earth are generally supposed to have determined the spots where active and extinct volcanos have burst forth; for several of these often affect a linear arrangement, their position seeming to have been determined by great lines of fissure. Another connecting link between the volcano and the hot spring is recognizable in the great abundance of hot springs in regions where volcanic eruptions still occur from time to time. It is also in the same districts that the waters occasionally attain the boiling temperature, while some of the associated stufas emit steam considerably above the boiling point. But in proportion as we recede from the great centres of igneous activity, we find the thermal waters decreasing in frequency and in their average heat, while at the same time they are most conspicuous in those territories where, as in Central France or the Eifel in Germany, there are cones and craters still so perfect in their form, and streams of lava bearing such a relation to the depth and shape of the existing valleys, as to indicate that the internal fires have become dormant in comparatively recent times. If there be exceptions to this rule, it is where hot springs are met with in parts of the Alps and Pyrenees which have been violently convulsed by modern earthquakes.

To pursue still further our comparison between the hot springs and the volcano, we may regard the water of the springs as representing those vast clouds of aqueous vapour which are copiously evolved for days, sometimes for weeks, in succession from craters during an eruption. But we shall perhaps be asked whether, when we contrast the work done by the two agents in question, there is not a marked failure of analogy in one respect —namely a want, in the case of the hot spring, of power to raise from great depths in the earth voluminous masses of solid matter corresponding to the heaps of scoriæ and streams of lava which the volcano pours out on the surface. To one who urges such an objection it may be said that the quantity of solid as well as gaseous matter transferred by springs from the interior of the earth to its surface is far more considerably than is commonly imagined. The thermal waters of Bath are far from being conspicuous among European hot springs for the quantity of mineral matter contained in them in proportion to the water which acts as a solvent; yet Professor Ramsay has calculated that if the sulphates of lime and of soda, and the chlorides of sodium and magnesium, and the other mineral ingredients which they contain, were solidified, they would form in one year a square column 9ft. in diameter, and no less than 140ft. in height. All this matter is now quietly conveyed by a stream of limpid water, in an invisible form, to the Avon, and by the Avon to the sea; but if, instead of being thus removed, it were deposited around the orifice of eruption, like the siliceous layers which incrust the circular basin of an Icelandic geyser, we should soon see a considerable cone built up, with a crater in the middle; and if the action of the spring were intermittent, so that ten or twenty years should elapse between the periods when solid matter was emitted, or (say) an interval of three centuries, as in the case of Vesuvius between 1306 and 1631, the discharge would be on so grand a scale as to afford no mean object of comparison with the intermittent outpourings of a volcano.

Dr. Daubeny, after devoting a month to the analysis of the Bath waters in 1833, ascertained that the daily evolution of nitrogen gas amounted to no less than 250 cubic feet in volume. This gas, he remarks, is not only characteristic of hot springs, but is largely disengaged from volcanic craters during eruptions. In both cases he suggests that the nitrogen may be derived from atmospheric air, which is always dissolved in rain-water, and which, when this water penetrates the earth's crust, must be carried down

to great depths, so as to reach the heated interior. When there, it may be subjected to deoxidating processes, so that the nitrogen, being left in a free state, may be driven upwards by the expansive force of heat and steam, or by hydrostatic pressure. This theory has been very generally adopted, as best accounting for the constant disengagement of large bodies of nitrogen, even where the rocks through which the spring rises are crystalline and unfossiliferous. It will, however, of course be admitted, as Professor Bischoff has pointed out, that in some places organic matter has supplied a large part of the nitrogen evolved.

Carbonic acid gas is another of the volatilised substances discharged by the Bath waters. Dr. Gustav Bischoff, in the new edition of his valuable work on chemical and physical geology, when speaking of the exhalations of this gas, remarks that they are of universal occurrence, and that they originate at great depths, becoming more abundant the deeper we penetrate. He also observes that, when the silicates which enter so largely into the composition of the oldest rock are percolated by this gas, they must be continually decomposed, and the carbonates formed by the new combinations thence arising must often augment the volume of the altered rocks. This increase of bulk, he says, must sometimes give rise to a mechanical force of expansion capable of uplifting the incumbent crust of the earth; and the same force may act laterally so as to compress, dislocate, and tilt the strata on each side of a mass in which the new chemical changes are developed. The calculations made by this eminent German chemist of the exact amount of distention which the origin of new mineral products may cause, by adding to the volume of the rocks, deserve the attention of geologists, as affording them aid in explaining those reiterated oscillations of level—those risings and sinkings of land—which have occurred on so grand a scale at successive periods of the past. There are probably many distinct causes of such upward, downward, and lateral movements, and any new suggestion on this head is most welcome; but I believe the expansion and contraction of solid rocks, when they are alternately heated and cooled, and the fusion and subsequent consolidation of mineral masses, will continue to rank, as heretofore, as the most influential causes of such movements.

The temperature of the Bath waters varies in the different springs from 117° to 120° F. This, as before stated, is exceptionally high, when we duly allow for the great distance of Bath from the nearest region of active or recently extinct volcanos and of violent earthquakes. The hot springs of Aix-la-Chapelle have a much higher temperature, viz., 135° F., but they are situated within forty miles of those cones and lava streams of the Eifel which, though they may have spent their force ages before the earliest records of history, belong, nevertheless, to the most modern geological period. Bath is about 400 miles distant from the same part of Germany, and 440 from Auvergne—another volcanic region, the latest eruptions of which were geologically coeval with those of the Eifel. When those two regions in France and Germany were the theatres of frequent convulsions, we may well suppose that England was often more rudely shaken than now; and such shocks as that of October, 1863, the sound and rocking motion of which caused so great a sensation as it traversed the southern part of the island, and seems to have been particularly violent in Herefordshire, may be only a languid reminder to us of a force of which the energy has been gradually dying out.

If you consult the geological map of the environs of this city, coloured by the Government surveyors, you will perceive that numerous lines of fault or displacement of the rocks are there laid down, and one of these has shifted the strata vertically as much as 200ft. Mr. Charles Moore pointed out to me in the spring of 1863, when I had the advantage of examining the geology of this district under his guidance, that there are other lines of displacement not yet laid down on the Ordnance Map, the existence of which must be inferred from the different levels at which the same formations crop out on the flanks of the hills to the north and south of the city. I have therefore little doubt that the Bath springs, like most other thermal waters, mark the site of some great convulsion and fracture which took place in the crust of the earth at some former period—perhaps not a very remote one, geologically speaking. The uppermost part of the rent through which the hot water rises is situated in horizontal strata of Lias and Trias, 300ft. thick; and this may be more modern than the lower part, which passes through the inclined and broken strata of the subjacent coal-measures, which are unconformable to the Trias. The nature and succession of these rocks penetrated by the Bath waters was first made out by the late William Smith in 1817, when a shaft was sunk in the vicinity in search for coal. The shock which opened a communication through the upper rocks may have been of a much later date than that which fractured the older and underlying strata; for there is a tendency in the earth's crust to yield most readily along lines of ancient fracture, which constitute the points of least resistance to a force acting from below.

If we adopt the theory already alluded to, that the nitrogen is derived from the deoxidation of atmospheric air carried down by rain water, we may imagine the supply of this water to be furnished by some mountainous region, perhaps a distant one, and that it descends through rents or porous rocks till it encounters some mass of heated matter by which it is converted into steam, and then driven upwards through a fissure. In its downward passage the water may derive its sulphate of lime, chloride of calcium, and other substances from the decomposition of the gypseous, saline, calcareous, and other constituents of the rocks which it permeates. The greater part of the ingredients are common to sea water, and might suggest the theory of a marine origin; but the analysis of the Bath springs by Merck and Galloway shows that the relative proportion of the solid matter is far from agreeing with that of the sea, the chloride of magnesium being absolutely in excess, that is, 14 grains of it per gallon for 12 of common salt; whereas in sea water there are 27 grains of salt, or chloride of sodium, to 4 of the chloride of magnesium. That some mineral springs, however, may derive an inexhaustible supply, through rents and porous rocks, from the leaky bed of the ocean, is by no means an unreasonable theory, especially if we believe that the contiguity of nearly all the active volcanos to the sea is connected with the access of salt water to the subterranean foci of volcanic heat.

Professor Roscoe, of Manchester, has been lately engaged in making a careful analysis of the Bath waters, and has discovered in them three metals which they were not previously known to contain—namely copper, strontium, and lithium; but he has searched in vain for cæsium and rubidium, those new metals, the existence of which has been revealed to us in the course of the last few years by what is called spectrum analysis. By this new method the presence of infinitesimal quantities, such as would have wholly escaped detection by ordinary tests, are made known to the eye by the agency of light. Thus, for example, a solid substance such as the residue obtained by evaporation from a mineral water is introduced on a platinum wire into a colourless gas-flame. The substance thus volatilised imparts its colour to the flame, and the light, being then made to pass through a prism, is viewed through a small telescope or spectroscope, as it is called, by the aid of which one or more bright lines or bands are seen in the spectrum, which, according to their position and colour, indicate the presence of different elementary bodies.

Professor Bunsen, of Heidelberg, led the way, in 1860, to the application of this new test to the hot waters of Baden-Baden and of Durkheim in the Palatinate. He observed in the spectrum some coloured lines of which he could not interpret the meaning, and was determined not to rest till he had found out what they meant. This was no easy task, for it was necessary to evaporate fifty tons of water to obtain 200 grains of what proved to be two new metals. Taken together, their proportion to the water was only as one to three million. He named the first cæsium, from the bluish-grey lines which it presented in the spectrum; and the second rubidium, from its two red lines. Since these successful experiments were made, thallium, so called from its green line, was discovered in 1861 by Mr. Crookes; and a fourth metal named indium, from its indigo-coloured band, was detected by Professor Richter, of Frieberg, in Saxony, in a zinc ore of the Hartz. It is impossible not to suspect that the wonderful efficacy of some mineral springs, both cold and thermal, in curing diseases, which no artificially prepared waters have as yet been able to rival, may be connected with the presence of one or more of these elementary bodies previously unknown; and some of the newly-found ingredients, when procured in larger quantities, may furnish medical science with means of combating diseases which have hitherto baffled all human skill.

While I was pursuing my inquiries respecting the Bath waters, I learned casually that a hot spring had been discovered at a great depth in a copper-mine near Redruth in Cornwall, having about as high a temperature as that of the Bath waters, and of which, strange to say, no account has yet been published. It seems that, in the year 1839, a level was driven from an old shaft so as to intersect a rich copper-mine at the depth of 1,350ft. from the surface. This lode or metalliferous fissure occurred in what were formerly called the United Mines, and which have since been named the Clifford Amalgamated Mines. Through the contents of the lode a powerful spring of hot water was observed to rise, which has continued to flow with undiminished strength ever since. At my request, Mr. Horton Davey, of Redruth, had the kindness to send up to London many gallons of this water, which have been analysed by Professor William Allen Miller, F.R.S., who finds that the quantity of solid matter is so great as to exceed by more than four times the proportion of that yielded by the Bath waters. Its composition is also in many respects very different; for it contains but little sulphate of lime, and is almost free from the salts of magnesium. It is rich in the chlorides of calcium and sodium, and it contains one of the new metals—cæsium, never before detected in any mineral spring in England; but its peculiar characteristic is the extraordinary abundance of lithium, of which a mere trace had been found by Professor Roscoe in the Bath waters; whereas, in this Cornish hot spring this metal constitutes no less than a twenty-sixth part of the whole of the solid contents, which, as before stated, are so voluminous. When Professor Miller exposed some of these contents to the test of spectrum analysis, he gave me an opportuniey of seeing the beautiful bright crimson line which the lithium produces in the spectrum.

Lithium was first made known in 1817 by Arfvedsen, who extracted it from petalite; and it was believed to be extremely rare, until Bunsen and Kirchhoff, in 1860, by means of spectrum analysis, showed that it was a most widely diffused substance, existing in minute quantities in almost all mineral waters and in the sea, as well as in milk, human blood, and the ashes of some plants. It has already been used in medicine, and we may therefore hope that now that it is obtainable in large quantities, and at a much cheaper rate than before the Wheal-Clifford hot spring was analysed, it may become of high value. According to rough estimate which has been sent to me by Mr. Davey, the Wheal-Clifford spring yields no less than 250 gallons per minute, which is almost equal to the discharge of the King's Bath or chief spring of this city. As to the gases emitted, they are the same as those of the Bath water—namely carbonic acid, oxygen, and nitrogen.

Mr. Warrington Smyth, who had already visited the Wheal-Clifford lode in 1855, re-examined it in July last, chiefly with the view of replying to several queries which I had put to him; and, in spite of the stifling heat, ascertained the geological structure of the lode and the exact temperature of the water. This last he found to be 122° F. at the depth of 1,350ft.; but he scarcely doubts that the thermometer would stand two or three degrees higher at the distance of 200ft. to the eastward, where the water is known to gush up more freely. The Wheal-Clifford lode is a fissure varying in width from 6ft. to 12ft., one wall consisting of elvan or porphyritic granite, and the other of killas or clay-slate. Along the line of the rent, which runs east and west, there has been a slight throw or shift of the rocks. The vein-stuff is chiefly formed of cellular pyrites of copper and iron, the porous nature of which allows the hot water to percolate freely through it. It seems, however, that in the continuation upwards of the same fissure little or no metalliferous ore was deposited, but in its place, quartz and other impermeable substances, which obstructed the course of the hot spring, so as to prevent its flowing out on the surface of the country. It has been always a favourite theory of the miners that the high temperature of this Cornish spring is due to the oxidation of the sulphurets of copper and iron, which are decomposed when air is admitted. That such oxidation must have some slight effect is undeniable; but that it materially influences the temperature of so large a body of water is out of the question. Its effect must be almost insensible; for Professor Miller has scarcely been able to detect any sulphuric acid in the water, and a minute trace only of iron and copper in solution.

When we compare the temperature of the Bath springs, which issue at a level of less than 100ft. above the sea, with the Wheal-Clifford spring found at a depth of 1,350ft. from the surface, we must of course make allowance for the increase of heat always experienced when we descend into the interior of the earth. The difference would amount to about 20° F., if we adopt the estimate deduced by Mr. Hopkins from an accurate series of observations made in the Monkwearmouth shaft, near Durham, and in the Dukinfield shaft near Manchester, each of them 2,000ft. in depth. In these shafts the temperature was found to rise at the rate of 1° F. for every increase of depth of from 65ft. to 70ft. But if the Wheal-Clifford spring, instead of being arrested in its upward course, had continued to rise freely through porous and loose materials so as to reach the surface, it would probably not have lost anything approaching to 20° F., since the renewed heat derived from below would have warmed the walls and contents of the lode, so as to raise their temperature above that which would naturally belong to the rocks at corresponding levels on each side of the lode. The almost entire absence of magnesium raises an obvious objection to the hypothesis of this spring deriving its waters from the sea; or if such a source be suggested for the salt and other marine products, we should be under the necessity of supposing the magnesium to be left behind in combination with some of the elements of the decomposed and altered rocks through which the thermal waters may have passed.

Hot springs are, for the most part, charged with alkaline and other highly soluble substances, and, as a rule, are barren of the precious metals, gold, silver, and copper, as well as of tin, platinum, lead, and many others, a slight trace of copper in the Bath waters being exceptional. Nevertheless there is a strong presumption that there exists some relationship between the action of thermal waters and the filling of rents with metallic ores. The component elements of these ores may, in the first instance, rise from great depths in a state of sublimation or of solution in intensely heated water, and may then be precipitated on the wall of a fissure as soon as the ascending vapours or fluids begin to part with some of their heat. Almost everything, save the alkaline metals, silica, and certain gases, may thus be left behind long before the spring reaches the earth's surface. If this theory be adopted, it will follow that the metalliferous portion of a fissure, originally thousands of feet or fathoms deep, will never be exposed in regions accessible to the miner until it has been upheaved by a long series of convulsions, and until the higher parts of the same rent, together with its contents and the rocks which it had traversed, have been removed by aqueous denudation. Ages before such changes are accomplished thermal and mineral springs will have ceased to act; so that the want of identity between the mineral ingredients of hot springs and the contents of metalliferous veins, instead of militating against their intimate relationship, is in favour of both being the complementary results of one and the same natural operation.

But there are other characters in the structure of the earth's crust more mysterious in their nature than the phenomena of metalliferous veins, on which the study of hot springs has thrown light—I allude to the metamorphism of sedimentary rocks. Strata of various ages, many of them once full of organic remains, have been rendered partially or wholly crystalline. It is admitted on all hands that heat has been instrumental in bringing about this re-arrangement of particles, which, when the metamorphism has been carried out to its fullest extent, obliterates all trace of the imbedded fossils. But as mountain masses many miles in length and breadth, and several thousands of feet in height, have undergone such alteration, it has always been difficult to explain in what manner an amount of heat capable of so entirely changing the molecular condition of sedimentary masses could have come into play without utterly annihilating every sign of stratification, as well as of organic structure.

Various experiments have led to the conclusion that the minerals which enter most largely into the composition of the metamorphic rocks have not been formed by crystallizing from a state of fusion, or in the dry way, but that they have been derived from liquid solutions, or in the wet way—a process requiring a far less intense degree of heat. Thermal springs, charged with carbonic acid and with hydro-fluoric acid (which last is often present in small quantities), are powerful causes of decomposition and chemical reaction in rocks through which they percolate. If, therefore, large bodies of hot water permeate mountain masses at great depths, they may in the course of ages superinduce in them a crystalline structure; and in some cases strata in a lower position and of older date may be comparatively unaltered, retaining their fossil remains undefaced, while newer rocks are rendered metamorphic. This may happen where the waters, after passing upwards for thousands of feet, meet with some obstruction, as in the case of the Wheal-Clifford spring, causing the same to be laterally diverted so as to percolate the surrounding rocks. The efficacy of such hydro-thermal action has been admirably illustrated of late years by the experiments and observations of Sénarmont, Daubrée, Delesse, Scheerer, Sorby, Sterry Hunt, and others.

The changes which Daubrée has shown to have been produced by the alkaline waters of Plombières, in the Vosges, are more especially instructive. These thermal waters have a temperature of 160° F., and were conveyed by the Romans to baths through long conduits or aqueducts. The foundations of some of their works consisted of a bed of concrete made of lime, fragments of brick and sandstone. Through this and other masonry the hot waters have been percolating for centuries, and have given rise to various zeolites—apophyllite and chabazite among others; also to calcareous spar, arragonite, and fluor spar, together with siliceous minerals, such as opal—all found in the interspaces of the bricks and mortar, or constituting part of their re-arranged materials. The quantity of heat brought into action in this instance in the course of 2,000 years has, no doubt, been enormous, although the intensity of it developed at any one moment has been always inconsiderable.

The study, of late years, of the constituent parts of granite has in like manner led to the conclusion that their consolidation has taken place at temperatures far below those formerly supposed to be indispensable. Gustav Rose has pointed out that the quartz of granite has the specific gravity of 2·6, which characterises silica when it is precipitated from a liquid solvent, and not that inferior density, namely 2·3, which belongs to it when it cools and solidifies in the dry way from a state of fusion.

But some geologists, when made aware of the intervention on a large scale, of water, in the formation of the component minerals of the granitic and volcanic rocks, appear of late years to have been too much disposed to dispense with intense heat when accounting for the formation of the crystalline and unstratified rocks. As water in a state of solid combination enters largely into the aluminous and some other minerals, and therefore plays no small part in the composition of the earth's crust, it follows that, when rocks are melted, water must be present, independently of the supplies of rain water and sea water which find their way into the region of subterranean heat. But the existence of water under great pressure affords no argument against our attributing an excessively high temperature to the mass with which it is mixed up. Still less does the point to which the melted matter must be cooled down before it consolidates or crystallizes into lava or granite afford any test of the degree of heat which the same matter must have acquired when it was melted and made to form lakes and seas in the interior of the earth's crust.

We learn from Bunsen's experiments on the Great Geyser in Iceland, that at the depth of only 74ft., at the bottom of the tube, a column of water may be in a state of rest, and yet possess a heat of 120° centigrade, or 248° F. What, then, may not the temperature of such water be at the depth of a few thousand feet? It might soon attain a white heat under pressure; and as to lava, they who have beheld it issue, as I did in 1858, from the south-western flanks of Vesuvius, with a surface white and

glowing like that of the sun, and who have felt the scorching heat which it radiates, will form a high conception of the intense temperature of the same lava at the bottom of a vertical column several miles high, and communicating with a great reservoir of fused matter, which, if it were to begin at once to cool down, and were never to receive future accessions of heat, might require a whole geological period before it solidified. Of such slow refrigeration hot springs may be among the most effective instruments, abstracting slowly from the subterranean molten mass that heat which clouds of vapour are seen to carry off in a latent form from a volcanic crater during an eruption, or from a lava-stream during its solidification. It is more than forty years since Mr. Scrope, in his work on volcanos, insisted on the important part which water plays in an eruption, when intimately mixed up with the component materials of lava, aiding, as he supposed, in giving mobility to the more solid materials of the fluid mass. But when advocating this igneoaqueous theory, he never dreamt of impugning the Huttonian doctrine as to the intensity of heat which the production of the unstratified rocks, those of the plutonic class especially, implies.

The exact nature of the chemical changes which hydrothermal action may effect in the earth's interior will long remain obscure to us, because the regions where they take place are inaccessible to man; but the manner in which volcanos have shifted their position throughout a vast series of geological epochs—becoming extinct in one region and breaking out in another—may, perhaps, explain the increase of heat as we descend towards the interior, without the necessity of our appealing to an original central heat or the igneous fluidity of the earth's nucleus.

I hinted, at the beginning of this Address, that the hot springs of Bath may be of no high antiquity, geologically speaking—not that I can establish this opinion by any positive proofs, but I infer it from the mighty changes which this region has undergone since the time when the British seas, rivers, and lakes were inhabited by the existing species of Testacea. It is already more than a quarter of a century since Sir Roderick Murchison first spoke of the Malvern Straits, meaning thereby a channel of the sea which once separated Wales from England. That such marine straits really extended, at a modern period, between what are now the estuaries of the Severn and the Dee has been lately confirmed in a satisfactory manner by the discovery of marine shells of recent species in drift covering the water shed which divides those estuaries. At the time when these shells were living, the Cotswold Hills, at the foot of which this city is built, formed one of the numerous islands of an archipelago into which England, Ireland, and Scotland were then divided. The amount of vertical movement which would be necessary to restore such a state of the surface as prevailed when the position of land and sea were so different would be very great.

Nowhere in the world, according to our present information, is the evidence of upheaval, as manifested by upraised marine shells, so striking as in Wales. In that country Mr. Trimmer first pointed out, in 1831, the occurrence of fossil shells in stratified drift, at the top of a hill called Moel Tryfaen, near the Menai Straits, and not far from the base of Snowdon. I visited the spot last year, in company with my friend Mr. Symonds, and we collected there not a few of the marine Testacea. Mr. Darbishire has obtained from the same drift no less than fifty-four fossil species, all of them now living either in high northern or British seas, and eleven of them being exclusively arctic. The whole fauna bears testimony to a climate colder than that now experienced in these latitudes, though not to such extreme cold as that applied by the fauna of some of the glacial drift of Scotland. The shells alluded to were procured at the extraordinary height of 1,360ft. above the sea level, and they demonstrate an upheaval of the bed of the sea to that amount in the time of the living Testacea. A considerable part of what is called the glacial epoch had already elapsed before the shelly strata in question were deposited on Moel Tryfaen, as we may infer from the polished and striated surfaces of rocks on which the drift rests, and the occurrence of erratic blocks smoothed and scratched, at the bottom of the same drift.

The evidence of a period of great cold in England and North America, in the times referred to, is now so universally admitted by geologists, that I shall take it for granted in this address, and briefly consider what may have been the probable causes of the refrigeration of central Europe at the era in question. One of these causes, first suggested eleven years ago by a celebrated Swiss geologist, has not, I think, received the attention which it well deserved. When I proposed, in 1833, the theory that alterations in physical geography might have given rise to those revolutions in climate which the earth's surface has experienced at successive epochs, it was objected by many that the signs of upheaval and depression were too local to account for such general changes of temperature. This objection was thought to be of peculiar weight when applied to the glacial period, because of the shortness of the time, geologically speaking, which has since transpired. But the more we examine the monuments of the ages which preceded the historical, the more decided become the proofs of a general alteration in the position, depth, and height of seas, continents, and mountain-chains since the commencement of the glacial period. The meteorologist also has been learning of late years that the quantity of ice and snow in certain latitudes depends not merely on the height of mountain-chains, but also on the distribution of the surrounding sea and land, even to considerable distances.

M. Escher von der Linth gave it as his opinion in 1852, that if it were true, as Ritter had suggested, that the great African desert, or Sahara, was submerged within the modern or post-tertiary period, that same submergence might explain why the Alpine glaciers had attained so recently those colossal dimensions which, reasoning on geological data, Venetz and Charpentier had assigned to them. Since Escher first threw out this hint, the fact that the Sahara was really covered by the sea at no distant period has been confirmed by many new proofs. The distinguished Swiss geologist himself has just returned from an exploring expedition through the eastern part of the Algerian desert, in which he was accompanied by M. Desor, of Neuchatel, and Professor Martins, of Montpellier. These three experienced observers satisfied themselves, during the winter of 1862 that the Sahara was under water during the period of the living species of Testacea. We had already learnt in 1856, from a memoir by M. Charles Laurent, that sands identical with those of the nearest shores of the Mediterranean, and containing, among other recent shell, the common cockle (*Cardium edule*), extend over a vast space from west to east in the desert, being not only found on the surface, but also brought up from depths of more than 20ft. by the Artesian auger. These shells have been met with at heights of more than 900ft. above the sea-level, and on ground sunk 300ft. below it; for there are in Africa, as in Western Asia, depressions of land below the level of the sea. The same cockle has been observed still living in several salt-lakes in the Sahara; and superficial incrustations in many places seem to point to the drying-up, by evaporation, of several inland seas in certain districts.

Mr. Tristram, in his travels in 1859, traced for many miles along the southern borders of the French possessions in Africa lines of inland sea-cliffs, with caves at their bases, and old sea-beaches forming successive terraces, in which recent shells and the casts of them were agglutinated together with sand and pebbles, the whole having the form of a conglomerate. The ancient sea appears once to have stretched from the Gulf of Cabes, in Tunis, to the west coast of Africa north of Senegambia, having a width of several hundred (perhaps where greatest, according to Mr. Tristram, 800) miles. The high lands of Barbary, including Morocco, Algeria, and Tunis, must have been separated at this period from the rest of Africa by a sea. All that we have learnt from zoologists and botanists in regard to the present fauna and flora of Barbary favours this hypothesis, and seems at the same time to point to a former connexion of that country with Spain, Sicily, and South Italy.

When speculating on these changes, we may call to mind that certain deposits, full of marine shells of living species, have long been known as fringing the borders of the Red Sea, and rising several hundred feet above its shores. Evidence has also been obtained that Egypt, placed between the Red Sea and the Sahara, participated in these great continental movements. This may be inferred from the old river-terraces, lately described by Messrs. Adams and Murie, which skirt the modern alluvial plains of the Nile, and rise above them to various heights, from 30ft. to 100ft. and upwards. In whatever direction, therefore, we look, we see grounds for assuming that a map of Africa in the glacial period would no more resemble our present maps of that continent than Europe now resembles North America. If, then, argues Escher, the Sahara was a sea in post-tertiary times, we may understand why the Alpine glaciers formerly attained such gigantic dimensions, and why they have left moraines of such magnitude on the plains of northern Italy and the lower country of Switzerland. The Swiss peasants have a saying, when they talk of the melting of the snow, that the sun could do nothing without the Föhn, a name which they give to the well-known sirocco. This wind, after sweeping over a wide expanse of parched and burning sand in Africa, blows occasionally for days in succession across the Mediterranean, carrying with it the scorching heat of the Sahara to melt the snows of the Apennines and Alps.

M. Denzler, in a memoir on this subject, observes that the Föhn blew tempestuously at Algiers on the 17th of July, 1841, and then crossing the Mediterranean, reached Marseilles in six hours. In five more hours it was at Geneva and the Valais, throwing down a large extent of forest in the latter district, while in the cantons of Zurich and the Grisons it suddenly turned the leaves of many trees from green to yellow. In a few hours new-mown grass was dried and ready for the haystack; for although in passing over the Alpine snows, the sirocco absorbs much moisture, it is still far below the point of saturation when it reaches the sub-Alpine country to the north of the great chain. MM. Escher and Denzler have both of them observed, on different occasions, that a thickness of one foot of snow has disappeared in four hours during the prevalence of this wind. No wonder, therefore, that the Föhn is much dreaded for the sudden inundations which it sometimes causes. The snow-line of the Alps was seen by Mr. Irscher, the astronomer, from his observatory at Neuchatel, by aid of the telescope, to rise sensibly every day while this

wind was blowing. Its influence is by no means confined to the summer season, for in the winter of 1852 it visited Zurich at Christmas, and in a few days all the surrounding country was stripped of its snow, even in the shadiest places and on the crests of high ridges. I feel the better able to appreciate the power of this wind from having myself witnessed in Sicily, in 1828, its effect in dissolving, in the month of November, the snows which then covered the summit and higher parts of Mount Etna. I had been told that I should be unable to ascend to the top of the highest cone till the following spring; but in thirty-six hours the hot breath of the sirocco stripped off from the mountain its white mantle of snow, and I ascended without difficulty.

It is well known that the number of days during which particular winds prevail, from year to year, varies considerably. Between the years 1812 and 1820 the Föhn was less felt in Switzerland than usual; and what was the consequence? All the glaciers, during those eight or nine years, increased in height, and crept down below their former limits in their respective valleys. Many similar examples might be cited of the sensitiveness of the ice to slight variations of temperature. Captain Godwin-Austen has lately given us a description of the gigantic glaciers of the western Himalaya in those valleys where the sources of the Indus rise, between the latitudes 35° and 36° N. The highest peaks of the Karakorum range attain in that region an elevation of 28,000ft. above the sea. The glaciers, says Captain Austen, have been advancing, within the memory of the living inhabitants, so as greatly to encroach on the cultivated lands, and have so altered the climate of the adjoining valleys immediately below, that only one crop a year can now be reaped from fields which formerly yielded two crops. If such changes can be experienced in less than a century, without any perceptible modification in the physical geography of that part of Asia, what mighty effects may we not imagine the submergence of the Sahara to have produced in adding to the size of the Alpine glaciers? If, between the years 1812 and 1820, a mere diminution of the number of days during which the sirocco blew could so much promote the growth and onward movement of the ice, how much greater a change would result from the total cessation of the same wind! But this would give no idea of what must have happened in the glacial period; for we cannot suppose the action of the south wind to have been suspended; it was not in abeyance, but its character was entirely different, and of an opposite nature, under the altered geographical conditions above contemplated. First, instead of passing over a parched and scorching desert, between the twentieth and thirty-fifth parallels of latitude, it would plentifully absorb moisture from a sea many hundreds of miles wide. Next, in its course over the Mediterranean, it would take up still more aqueous vapour; and when, after complete saturation, it struck the Alps, it would be driven up into the higher and more rarefied regions of the atmosphere. There the aerial current, as fast as it was cooled, would discharge its aqueous burden in the form of snow, so that the same wind which is now called "the devourer of ice" would become its principal feeder.

If we thus embrace Escher's theory, as accounting in no small degree for the vast size of the extinct glaciers of Switzerland and Northern Italy, we are by no means debarred from accepting at the same time Charpentier's suggestion, that the Alps in the glacial period were 2,000ft. or 3,000ft. higher than they are now. Such a difference in altitude may have been an auxiliary cause of the extreme cold, and seems the more probable now that we have obtained unequivocal proofs of such great oscillations of level in Wales within the period under consideration. We may also avail ourselves of another source of refrigeration which may have coincided in time with the submergence of the Sahara, namely, the diversion of the Gulf-stream from its present course. The shape of Europe and North America, or the boundaries of sea and land, departed so widely in the glacial period from those now established, that we cannot suppose the Gulf-stream to have taken at that period its present north-western course across the Atlantic. If it took some other direction, the climate of the north of Scotland would, according to the calculations of Mr. Hopkins, suffer a diminution in its average annual temperature of 12° F., while that of the Alps would lose 2° F. A combination of all the conditions above enumerated would certainly be attended with so great a revolution in climate as might go far to account for the excessive cold which was developed at so modern a period in the earth's history. But even when we assume all three of them to have been simultaneously in action, we have by no means exhausted all the resources which a difference in the geographical condition of the globe might supply. Thus, for example, to name only one of them, we might suppose that the height and quantity of land near the north pole was greater at the era in question than it is now.

The vast mechanical force that ice exerted in the glacial period has been thought by some to demonstrate a want of uniformity in the amount of energy which the same natural cause may put forth at two successive epochs. But we must be careful, when thus reasoning, to bear in mind that the power of ice is here substituted for that of running water. The one becomes a mighty agent in transporting huge erratics, and in scouring, abrading, and polishing rocks; but meanwhile the other is in abeyance. When, for example, the ancient Rhone glacier conveyed its moraines from the upper to the lower end of the Lake of Geneva, there was no great river, as there now is, forming a delta many miles in extent, and several hundred feet in depth, at the upper end of the lake.

The more we study and comprehend the geographical changes of the glacial period, and the migrations of animals and plants to which it gave rise, the higher our conceptions are raised of the duration of that subdivision of time, which, though vast when measured by the succession of events comprised in it, was brief, if estimated by the ordinary rules of geological classification. The glacial period was, in fact, a mere episode in one of the great epochs of the earth's history; for the inhabitants of the lands and seas, before and after the grand development of snow and ice, were nearly the same. As yet we have no satisfactory proof that man existed in Europe or elsewhere during the period of extreme cold; but our investigations on this head are still in their infancy. In an early portion of the post-glacial period it has been ascertained that man flourished in Europe; and in tracing the signs of his existence, from the historical ages to those immediately antecedent, and so backward into more ancient times, we gradually approach a dissimilar geographical state of things, when the climate was colder, and when the configuration of the surface departed considerably from that which now prevails.

Archeologists are satisfied that in central Europe the age of bronze weapons preceded the Roman invasion of Switzerland; and prior to the Swiss-lake dwellings of the bronze age were those in which stone weapons alone were used. The Danish kitchen-middens seem to have been about the same date; but what M. Lartet has called the reindeer period of the south of France was probably anterior, and connected with a somewhat colder climate. Of still higher antiquity was that age of ruder implements of stone such as were buried in the fluviatile drift of Amiens and Abbeville, and which were mingled in the same gravel with the bones of extinct quadrupeds, such as the elephant, rhinoceros, bear, tiger, and hyena. Between the present era and that of those earliest vestiges yet discovered of our race, valleys have been deepened and widened, the course of subterranean rivers which once flowed through caverns has been changed, and many species of wild quadrupeds have disappeared. The bed of the sea, moreover, has in the same ages been lifted up, in many places hundreds of feet, above its former level, and the outlines of many a coast entirely altered.

MM. de Verneuil and Louis Lartet have recently found, near Madrid, fossil teeth of the African elephant, in old valley drift, containing flint implements of the same antique type, as those of Amiens and Abbeville. Proof of the same elephant having inhabited Sicily in the Postpliocene and probably within the Human period had previously been brought to light by Baron Anca, during his exploration of the bone caves of Palermo. We have now, therefore, evidence of man having co-existed in Europe with three species of elephant, two of them extinct (namely, the mammoth and the *Elephas antiquus*), and a third the same as that which still survives in Africa. As to the first of these—the mammoth—I am aware that some writers contend that it could not have died out many tens of thousands of years before our time, because its flesh has been found preserved in ice, in Siberia, in so fresh a state as to serve as food for dogs, bears, and wolves; but this argument seems to me fallacious. Middendorf, in 1843, after digging through some thickness of frozen soil in Siberia, came down upon an icy mass, in which the carcase of a mammoth was imbedded, so perfect that, among other parts, the pupil of its eye was taken out, and is now preserved in the Museum of Moscow. No one will deny that this elephant had lain for several thousand years in its icy envelope; and if it had been left undisturbed, and the cold had gone on increasing, for myriads of centuries, we might reasonably expect that the frozen flesh might continue undecayed until a second glacial period had passed away.

When speculations on the long series of events which occurred in the glacial and post-glacial periods are indulged in, the imagination is apt to take alarm at the immensity of the time required to interpret the monuments of these ages, all referable to the era of existing species. In order to abridge the number of centuries which would otherwise be indispensable, a disposition is shown by many to magnify the rate of change in prehistoric times, by investing the causes which have modified the animate and inanimate world with extraordinary and excessive energy. It is related of a great Irish orator of our day, that when he was about to contribute somewhat parsimoniously towards a public charity, he was persuaded by a friend to make a more liberal donation. In doing so he apologised for his first apparent want of generosity by saying that his early life had been a constant struggle with scanty means, and that "they who are born to affluence cannot easily imagine how long a time it takes to get the chill of poverty out of one's bones." In like manner, we of the living generation, when called upon to make grants of thousands of centuries in order to explain the events of what is called the modern period, shrink naturally at first from making what seems so lavish an expenditure of past time. Throughout our early education we have been accustomed to such strict economy in all that relates to the chronology of the earth and its inhabitants in remote ages, so fettered have we been

by old traditional beliefs, that even when our reason is convinced, and we are persuaded that we ought to make more liberal grants of time to the geologist, we feel how hard it is to get the chill of poverty out of our bones.

I will now briefly allude, in conclusion, to two points on which a gradual change of opinion has been taking place among geologists of late years. First, as to whether there has been a continuous succession of events in the organic and inorganic worlds, uninterrupted by violent and general catastrophes; and secondly, whether clear evidence can be obtained of a period antecedent to the creation of organic beings on the earth. I am old enough to remember when geologists dogmatised on both these questions in a manner very different from that in which they would now venture to indulge. I believe that by far the greater number now incline to opposite views from those which were once most commonly entertained. On the first point it is worthy of remark that although a belief in sudden and general convulsions has been losing ground, as also the doctrine of abrupt transitions from one set of species of animals and plants to another of a very different type, yet the whole series of the records which have been handed down to us are now more than ever regarded as fragmentary. They ought to be looked upon as more perfect, because numerous gaps have been filled up, and in the formations newly intercalated in the series we have found many missing links and various intermediate gradations between the nearest allied forms previously known in the animal and vegetable worlds. Yet the whole body of monuments which we are endeavouring to decipher appears more defective than before. For my own part, I agree with Mr. Darwin in considering them as a mere fraction of those which have once existed, while no approach to a perfect series was ever formed originally, it having never been part of the plan of Nature to leave a complete record of all her works and operations for the enlightenment of rational beings who might study them in after-ages.

In reference to the other great question, or the earliest date of vital phenomena on this planet, the late discoveries in Canada have at least demonstrated that certain theories founded in Europe on mere negative evidence were altogether delusive. In the course of a geological survey, carried on under the able direction of Sir William E. Logan, it has been shown that northward of the river St. Lawrence there is a vast series of stratified and crystalline rocks of gneiss, mica-schist, quartzite, and limestone, about 40,000ft. in thickness, which have been called Laurentian. They are more ancient than the oldest fossiliferous strata of Europe, or those to which the term primordial had been rashly assigned. In the first place, the newest part of this great crystalline series is uncomformable to the ancient fossiliferous or so-called primordial rocks which overlie it; so that it must have undergone disturbing movements before the latter or primordial set were formed. Then again, the older half of the Laurentian series is unconformable to the newer portion of the same. It is in this lowest and most ancient system of crystalline strata that a limestone, about a thousand feet thick, has been observed, containing organic remains. These fossils have been examined by Dr. Dawson, of Montreal, and he has detected in them, by aid of the microscope, the distinct structure of a large species of Rhizopod. Fine specimens of this fossil, called *Eozoon Canadense*, have been brought to Bath by Sir William Logan, to be exhibited to the members of the Association. We have every reason to suppose that the rocks in which these animal remains are included are of as old a date as any of the formations named azoic in Europe, if not older, so that they preceded in date rocks once supposed to have been formed before any organic beings had been created.

But I will not venture on speculations respecting "the signs of a beginning," or "the prospects of an end," of our terrestrial system—that wide ocean of scientific conjecture on which so many theorists before my time have suffered shipwreck. Without trespassing longer on your time, I will conclude by expressing to you my thanks for the honour you have done me in asking me to preside over this meeting. I have every reason to hope, from the many members and distinguished strangers whom I already see assembled here, that it will not be inferior in interest to any of the gatherings which have preceded it.

SUMMARY OF THE PROPERTIES OF CERTAIN STREAM-LINES.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.SS.L. & E.

1. The investigation of which the present paper is a summary, consists of three parts. It is a sequel to one of which an abstract was read at the meeting of the British Association in 1863, and which has since been printed in full in the Philosophical Transactions. It relates to the paths in which the particles of a liquid move past a solid body. In the previous paper (which was confined to motion in two dimensions) those were called "Water-Lines," and were treated of with a view mainly to their use as figures for the horizontal water-lines of ships. In the present paper they are called "Stream-Lines," as being a more general term, and one less liable to be misunderstood when motion in three dimensions is considered.

The term "Neoid" (νηοειδὴς, ship-like) proposed in the previous paper as a general name for water-line curves in two dimensions, may be extended to all the stream-lines discussed in the present paper; for they are all applicable to certain lines on the surface of a ship.

Part I.—*On some Exponential Stream-Lines in two Dimensions.*

2. It is well known that amongst the functions which satisfy the conditions of liquid motion in two dimensions, are comprehended all those of the form

$$y + \Sigma.\, e^{ay} \cos. ax.$$

Such functions as the above obviously represent curves consisting of an endless series of repetitions of the same figure; and many of those curves resemble the profiles of waves.

3. The first part of the investigation consists of a discussion of the properties of the curves represented by the simplest of those exponential stream-line functions, viz.

$$b = y - e^{-y} \cos x. \quad \ldots\ldots\ldots\ldots \quad (1$$

By giving to b a set of values in arithmetical progression, this function is made to represent a set of stream-lines, dividing an indefinitely extended plane layer of liquid into a series of curved streams of equal flow. Each of those stream-lines consists of an endless series of repetitions of the same figure, the length parallel to x of each repetition being 2π; and each repetition consists of a pair of symmetrical halves.

4. The graphic construction of those stream lines is very easy, by the aid of a general method of constructing curves first used by Professor Clerk Maxwell, and applied by the present author to stream-lines in the previous investigation already referred to.

Draw a series of straight lines parallel to x, and having for their equation

$$y = m,$$

—the values of m being in arithmetical progression, positive and negative, with a fraction for their common difference, which should be the smaller the more accurate the drawing is to be. Then draw the series of curves of hyperbolic-logarithmic cosines, having for their equation

$$e^{-y} \cos x = m',$$

—the values of m' positive and negative, forming an arithmetical progression, and having the same common difference with those of m. The curves with positive values of m' lie between $x = 0$ and $x = \frac{\pi}{2}$; those with negative values between $x = \frac{\pi}{2}$ and $x = \pi$; and the straight line parallel to y, at $\frac{\pi}{2}$, is an asymptote to them all. One and the same mould serves to trace all those curves; for they differ only in the maximum value of y, which is $\pm$ hyp. log m'. Then trace a series of curves diagonally through the intersections of the network already drawn, in such a manner as to make $m - m' = b$ for each curve; these will be the required stream-lines.

5. The ordinates for which x is an odd multiple of $+\frac{\pi}{2}$ are asymptotes to all the stream-lines at the negative side of the axis of x, and are also intersected by each stream-line at the point where $y = b$.

6. Maximum values of y for all the stream-lines occur on the ordinates where x has the value 0, or any even multiple of $\pm \pi$.

7. Minimum values of $+y$ and $-y$ occur on each ordinate where x is an odd multiple of $\pm \pi$, but for those stream-lines only for which $b > 1$. The stream-lines for which $b < 1$ do not intersect those ordinates.

8. The stream-line for which $b = 1$ consists of an endless series of equal and similar curves, each adjacent pair of which cut each other at right angles and the axis of x at angles of 45°, in the points where x is an odd multiple of $\pm \pi$.

9. Each stream-line for which $b < 1$ consists of an endless series of equal and similar detached curves, having maximum and minimum values of x given by the equation

$$\cos x = -e^{-1+b}$$

10. Each stream-line for which $b > 1$ is made up as follows:—At the positive side of the axis of x, a continuous curve, presenting an endless series of equal and similar waves; at the negative side, an endless series of equal and similar detached curves.

11. The wave-line curves thus formed, as they become more remote from the axis of x (that is, as b increases), approximate more and more nearly to the trochoidal form, which is known to be that of free waves in deep water; and so rapid is that approximation, that though for $b = 1$ the difference between the two kinds of wave-line is very great, it becomes almost undistinguishable for $b = 1\frac{1}{4}$.

12. Quantities proportional to the component velocities of a particle and to the square of its resultant velocity, are derived from the stream-line function as follows:—

$$\left.\begin{aligned} u &= \frac{db}{dy} = 1 + e^{-y}\cos x = 1 + y - b, \\ v &= -\frac{db}{dx} = -e^{-y}\sin x; \end{aligned}\right\} \ldots\ldots\ldots \quad (2)$$

$$\left.\begin{aligned} u^2 + v^2 &= 1 + 2e^{-y}\cos x + e^{-2y} \\ &= 1 + 2(y - b) + e^{-2y} \end{aligned}\right\} \ldots\ldots\ldots \quad (3)$$

At the point where the curves $b = 1$ cross the axis of x, both the component velocities are null. The unit of velocity in each of those expressions is the velocity of a particle at an infinite distance in the positive direction from the axis of x, for which particle we have $u = 1$, $v = 0$.

13. Suppose the plane of x and y to be vertical, and y to be positive down-

wards; let the absolute value of the unit of measure (that is, the radius of the circle whose circumference is a wave-length) be denoted by R; and let the heaviness (or weight of a unit of volume) of the liquid be W. Then the stream-lines for which b is not less than 1 may represent the profiles of a series of forced waves, capable of travelling with the absolute velocity

$$c = \sqrt{g\,\mathrm{R}}, \qquad \ldots\ldots (4)$$

being the same with that of free waves of the same length; and the absolute values of the velocities of any particle relatively to still water will be

$$\left.\begin{array}{l} \text{horizontal component, } c\,(u - 1) = c\,e^{-y}\cos x\,; \\ \text{vertical component, } c\,v = -\,c\,e^{-y}\sin x\,; \\ \text{resultant velocity, } c\sqrt{\left\{(u-1)^2 + v^2\right\}} = c\,e^{-y} \end{array}\right\} \ldots\ldots (5)$$

14. Those forced waves differ from free waves in the following respects. First, in free or trochoidal waves, each wave-surface is a surface of constant pressure, so that the upper surface of the liquid needs no pressure to be applied to it to compel the waves to travel; whereas in the waves now in question the pressure at each wave-surface is not constant, being expressed by the following formula,

$$p = \text{constant} + \mathrm{W}\,b - \frac{\mathrm{W\,R}\,e^{-2y}}{2} \qquad \ldots\ldots (6)$$

of which the last term is variable; and the upper surface requires a pressure varying according to this law to be applied to it, in order to compel the waves to travel.

Secondly, free or trochoidal waves begin to break as they reach the cycloidal form, in which the surface near the crest is vertical, and the crest forms a cusp; whereas in the waves now in question the steepest possible form, which cannot be passed without breaking, is that of the stream-line $b = 1$, whose crest is formed by two surfaces meeting each other at right angles, and sloping in opposite directions at 45°. Thirdly, the particles of water in free waves revolve in circles, and do not permanently advance; whereas the orbit of each particle in the waves now in question is an endless coiled or looped curve, in which each revolution is accompanied by an advance. The figure of that orbit is determined by the ratio which its radius of curvature bears to the unit of measure R, viz.,

$$\frac{\sqrt{\left\{(u-1)^2 + v^2\right\}}}{u} = \frac{e^{-y}}{1 + y - b} \qquad \ldots\ldots (7)$$

The waves whose motion is investigated by Professor Stokes in the Cambridge Transactions are of a character intermediate between trochoidal waves and those here considered.

15. As waves are frequently observed whose figures present a general likeness to that now described, it is probable that a pressure approximating to the law expressed by equation (6) may be exerted upon them by the wind.

16. It is evident that a pressure varying according to that law, or nearly so, will be exerted by the bottom of a ship upon the water, when the figures of the buttock-lines, or vertical longitudinal sections of her after-body, are exponential stream-lines, or trochoidal waves approximating to them, as in Mr. Scott Russell's system of shipbuilding.

PART. II.—*On Lissoneoïds in three Dimensions.*

17. The second part of the investigation relates to the mathematical properties of stream-lines of smoothest gliding in three dimensions. The properties of such lines in two dimensions were investigated, and the name "Lissoneoids" proposed for them, in the paper already referred to. Their essential mechanical properties are, to have fewer and less abrupt maxima and minima of the speed of gliding of the particles on them than on other stream-lines belonging to the same mathematical class, and to be the fullest lines of their class consistently with not raising more waves than are unavoidable, when they are employed as the lines of a ship.

18. The mathematical condition which such a stream-line fulfils is, that at the midship-section or broadest part of the solid to which the line belongs, two points of maximum and one of minimum speed of gliding coalesce into one point.

19. The investigation shows that the before-mentioned condition is expressed mathematically as follows, for any stream-line which at its greatest breadth is parallel to the axis of x. Let u be the longitudinal component, and v and w the transverse components of the speed of gliding of a particle along the stream-line; then at the point where that line crosses the midship section, supposing that we have $v = 0$, $w = 0$, the following equation must be fulfilled:—

$$u\frac{d^2 u}{d x^2} + \frac{d\,u^2}{d\,y^2} + \frac{d\,u^2}{d\,z^2} = 0. \qquad \ldots\ldots (8)$$

The corresponding equation in two dimensions is formed by omitting the term in $\frac{d\,u}{d\,z}$.

PART III.—*On some Stream-lines of Revolution.*

20. The third part of the investigation relates to the stream-lines in which particles flow past certain totally immersed oval solids of revolution, bearing the same relation to a sphere that the oval neoids described in the previous paper bear to a circle. These lie upon a series of surfaces of revolution, and are the sections of those surfaces by planes passing through the axis.

21. Let the axis of figure be that of x, and let there be two points in it, called *foci*, situated at the distances $+\,a$ and $-\,a$ from the origin. The distance a may be called the *eccentricity*. Let the perpendicular distance of any particle from the axis be denoted by y; let f be a constant length, called the *parameter*; and let b be the radius of a cylinder which is an asymptote to a given stream-line surface. Then the equation of that surface is as follows:—

$$b^2 = y^2 - f^2\left\{\frac{x + a}{\sqrt{\left\{(x+a)^2 + y^2\right\}}} - \frac{x - a}{\sqrt{\left\{(x-a)^2 + y^2\right\}}}\right\} \ldots\ldots (9)$$

Or, in another form, let θ and θ' be the angles which two lines drawn from the given particle to the foci $(+\,a)$ and $(-\,a)$ respectively make with the axis of $+\,x$; then—

$$b^2 = y^2 - f^2\,(\cos\theta' - \cos\theta) \qquad \ldots\ldots (10)$$

22. For the primitive oval solid, $b = 0$; and by giving b^2 a series of values increasing in arithmetical progression, a series of stream-line surfaces are formed, of gradually increasing width, which divide the liquid mass into a series of concentric tubular streams of equal discharge.

23. The graphic construction of the stream-lines is as follows. From each of the foci draw a set of diverging straight lines, making angles with the axis whose cosines are in arithmetical progression, the common difference being a sufficiently small fraction. Through the network formed by these lines trace diagonally a series of curves traversing the two foci. (The equation of each of those curves is $\cos\theta' - \cos\theta = m$, and they are identical with the lines of force of a magnet having its poles at the foci.) Multiply the parameter (f) by the square roots of the terms of the arithmetical progression, and draw a series of straight lines parallel to the axis and at the distances from it so found; these will be the asymptotes expressed by the equation $b = f\sqrt{m}$. Then through the network formed by those parallel straight lines and the before-mentioned series of curves trace diagonally a new series of curves, which will be the stream-lines required.

24. The stream-lines thus drawn closely resemble those in two dimensions, but are somewhat fuller. For those at a distance from the axis, the difference of form is scarcely perceptible; for those near the axis, and especially for the primitive oval, the greater fulness of form is conspicuous.

25. The ratios of the component velocities of a particle on a stream-line surface of revolution to the velocity of a particle at an infinite distance from the disturbing solid are given by the expressions

$$u = \frac{b\,d\,b}{y\,d\,y}; \quad v = -\,\frac{b\,d\,b}{y\,d\,x} \qquad \ldots\ldots (11)$$

26. By applying to those stream-lines of revolution the principles of the second part of the investigation, it is found that the radius (b) of the asymptotic cylinder of a lissoneoid surface of revolution bears the following relation to the greatest radius (y_0) of the surface itself, and to the eccentricity (a) of the set of surfaces to which it belongs:—

$$b^2 = y_0^2 - 2\,(a^2 + y_0^2)\cdot\frac{3\,y_0^2 - 2\,a^2}{3\,y_0^2 + 2\,a^2} \qquad \ldots\ldots (12)$$

In order that this equation may be real, $\frac{y_0}{a}$ must not be less than $\sqrt{\frac{2}{3}}$, nor greater than $\left(\frac{4}{3}\right)^{\frac{1}{4}}$. The corresponding parameter is found by the general formula

$$f^2 = \frac{(y_0^2 - b^2)\sqrt{a^2 + y_0^2}}{2\,a} \qquad \ldots\ldots (13)$$

In the oval lissoneoid of revolution,

$$b^2 = 0,\ \frac{y_0^2}{a^2} = \frac{2}{\sqrt{3}} = 1{\cdot}1547;\ \text{and}\ \frac{f^2}{a^2} = \frac{\sqrt{\sqrt{3} + 2}}{3} = 0{\cdot}644.$$

Addendum to Part I., Article 14.

Since the preceding summary was written, the author has found that the property of beginning to break when the two slopes of the crest meet at right angles, being inclined in opposite directions at 45°, belongs to all possible waves in which "molecular rotation" is null; that is, in which

$$\frac{d\,u}{d\,y} - \frac{d\,v}{d\,x} = 0.$$

ON THE POWER REQUIRED TO OVERCOME THE VIS INERTIÆ OF RAILWAY TRAINS; WITH A DESCRIPTION OF A HORIZONTAL PROPELLER INTENDED TO ACT GENERALLY AS AN AUXILIARY TO THE LOCOMOTIVE POWER, AND TO FORM THE PRINCIPAL, IF NOT THE SOLE, PROPELLING POWER ON RAILWAYS HAVING FREQUENT STATIONS.

By W. P. BARLOW.

When the North Kent Railway was opened in 1851 to the public, the locomotive engineer called my attention to the fact that a greater weight of coke was consumed than with similar trains on the main line of the South Eastern Railway, and that the necessity for using two engines to one train more frequently occurred.

Upon an examination of the subject, assisted by experiments, and embodied in a paper read before the Royal Society, I arrived at the conclusion that the principal cause of the difference was the more frequent stations and more frequent necessity of overcoming the vis inertiæ of the trains; that is to say, the stations being so

near together there was not sufficient time for the engine to give the train its full velocity before it became necessary to use the brake to stop it at the next station.

In order to distinguish between power used to overcome the ordinary resistance from friction, from that of the power required to put the mass in motion, I obtained the velocity which a train of a given weight would acquire with a given tractive power in the usual manner, as follows:—

Let A represent the tractive force on the surface of the driving wheel.
T the weight of the train in pounds.
S the length of the plane.
G the inclination of the plane.
F the friction of the train per ton.

$\frac{T}{G}$ = pounds resistance from gravity.

$\frac{T\,F}{2240}$ pounds resistance from friction.

$A \pm \frac{T}{G} - \frac{T\,F}{2240}$ = moving force in pounds.

$\dfrac{A \pm \frac{T}{G} - \frac{T}{2240} F}{T}$ = inclination of the plane, on which a body without friction would descend with equal velocities and in equal times.

$\left(\dfrac{A \times \frac{T}{G} - \frac{T}{2240}}{}\right)$ S = perpendicular height through which a body must fall to acquire the same velocity.

Then by the law of constant accelerating forces V = the velocity in feet per second is—

$$2\sqrt{\left(\dfrac{\pm \frac{T}{G}\ \frac{T\,F}{2240}}{T}\right) S\ 16\tfrac{1}{3}}$$

and t = the time in seconds $2\sqrt{\left(A \pm \frac{T}{G}\ \frac{T\,F}{2240}\right) S\ 16\tfrac{1}{3}}$

$$\left(A \dfrac{T}{\pm \frac{T}{G}\ \frac{T}{2240} F}\right) \tfrac{1}{32}\tfrac{2}{3}, \text{ or, } t \left(A \dfrac{T}{\pm \frac{T}{G}\ \frac{T\,F}{2240}}\right) \dfrac{V}{32\frac{2}{3}}$$

The following table has been calculated from the above formula, giving the velocities with different weights of trains and tractive power:—

	Tractive Force 2,000lbs.	Tractive Force 2,500lbs.	Tractive Force. 3,000lbs.	Tractive Force 3,500lbs.	Tractive Force 4,000lbs.	Tractive Force 8,000lbs.
	TRAIN OF TWENTY-FIVE TONS.					
Velocity at ½ mile...........	50·456	57·235	63·06	68·	73·548	103·3
„ 1 „	71·4	80·9	89·202	96·157	104·012	
„ 1½ „	87·556	99·00	109·24	117·776	127·391	
„ 2 „	101·116	114·43	126·153	136·	147·085	206·
	Train of 50 Tons.					
Velocity at ½ mile...........	33·68	38·59	42·93	46·933	50·55	
„ 1 „	47·668	54·61	60·73	66·336	71·49	
„ 1½ „	58·38	66·89	74·378	81·287	87·55	
„ 2 „	67·41	77·24	85·897	93·866	101·10	
	Train of 75 Tons.					
Velocity at ½ mile...........	25·73	29·947	33·69	37·019	40·106	
„ 1 „	36·407	42·377	47·66	52·36	56·725	
„ 1½ „	44·58	51·91	58·38	64·124	69·148	
„ 2 „	51·489	59·92	67·41	74·038	80·203	
	Train of 100 Tons.					
Velocity at ½ mile...........	20·617	24·548	27·93	30·94	33·69	
„ 1 „	29·199	34·748	39·5	43·76	47·66	
„ 1½ „	35·74	42·54	48·38	53·61	58·38	
„ 2 „	41·28	49·13	55·86	61·88	67·38	
	Train of 150 Tons.					
Velocity at ½ mile...........	13·72	17·51	20·57	23·26	25·73	
„ 1 „	19·42	20·77	29·13	33·01	36·4	
„ 1½ „	23·78	30·34	35·68	40·33	44·58	
„ 2 „	27·499	35·06	41·2	46·52	51·46	
	Train of 200 Tons.					
Velocity at ½ mile...........	8·377	12·60	15·73	18·34	20·61	33·69
„ 1 „	11·832	17·82	22·26	26·01	29·15	47·61
„ 1½ „	14·51	21·84	27·29	31·89	35·74	58·38
„ 2 „	16·8	25·62	31·5	36·68	41·22	67·38

In order to test this table with practical results, I compared these velocities with those obtained by Mr. H. Stephenson at the Atmospheric Railway at Dalkey, where the tractive power could be more correctly obtained than in a locomotive. At the same time a series of experiments were made by me on locomotive trains on the South Eastern Railway, to which I was enabled to add some made by the Gauge Commissioners at which I was present.

These results—which are given in Tables Nos. 2 and 3—sufficiently prove the accuracy of the calculations as the differences are those which would arise from evident causes.*

* In the experiments on the South Eastern Railway, two miles were required to overcome the inertia; in those on the Great Western Railway, four miles.

In the table of locomotive experiments no comparison is made with calculated results, because it is impossible to estimate the tractive force correctly, but by comparison with Table No. 1 it was evident the increase of velocity followed the same law until the tractive power was reduced by the speed of the engine.

From the actual results, as well as the calculated results, it was apparent that the locomotives then in use were insufficient to keep time, and that greater tractive power must be given in order to overcome the vis inertiæ more rapidly, and the only remedy that then occurred was accordingly adopted by my advice, viz., increased cylinders, but at the expense of heavier engines, and a greater destruction of permanent way.

The tendency to give more tractive power has increased with the increase of traffic and length of trains, and I was recently so struck with the greater rapidity of the starting of the trains from the Blackheath Station, near which I reside, that I decided to observe the velocity and found that eighteen miles per hour is frequently obtained by the time the last carriage leaves the platform, thus indicating a tractive power of 5,400lbs.

It then occurred to me, bearing in mind my previous investigation, that if this peed could be increased to 35 or 36 miles by any stationary power acting the length of the platform, that the necessity for locomotives on lines with frequent stations would be avoided, as the train would have sufficient momentum or vis viva, to run a mile without a great diminution of speed. A large economy would be obtained by substituting stationary for locomotive power, and a greater average speed with the same power, because the vis inertiæ would be more rapidly overcome, besides which the noise and vibration of locomotives would be avoided.

The result obtained of greater average speed, with the same power (that is to say, with a greater tractive power, a proportionately less distance), is apparently an anomaly, but its correctness will be readily understood. It is, however, first necessary to know the distance a train, having a given speed or vis viva, will run before it comes to a state of rest.

There does not appear to have been any experiments recently made directly on this subject but those by Mr. Pambour, on the Sutton incline of the Liverpool and Manchester Railway, who gives the result with great accuracy, from numerous experiments.

From a point taken on the Sutton incline, at 50 chains from the foot of that plane, 34 distances of 10 chains, or 33ft. each, were measured. At each of these points, a numbered pole was fixed, and the level exactly taken. The following table shows the level at each point:—

Number of the Posts.	Distance from the first Post in feet.	Vertical descent below the first Post in feet and decimals of feet.		Number of the Posts.	Distance from the first Post in feet.	Vertical descent below the first post in feet and decimals of feet.	
0	0	0	Starting point.	18	5,940	36·66	
1	330	3·47		19	6,270	36·80	
2	660	7·07		20	6,600	36·92	
3	990	10·62		21	6,930	37·06	
4	1,320	14·36		22	7,260	37·14	
5	1,650	18·17		23	7,590	37·22	
6	1,980	21·77		24	7,920	37·37	
7	2,310	25·53		25	8,250	37·34	
8	2,640	28·98		26	8,580	37·63	
9	2,970	32·07		27	8,910	37·92	
10	3,300	34·61	Foot of the inclined plane or rather middle point of the continued curve.	28	9,240	38·14	
11	3,630	35·06		29	9,570	38·35	
12	3,960	35·19		30	9,900	38·54	
13	4,290	35·23		31	10,230	38·67	
14	4,620	35·37		32	10,560	38·77	
15	4,950	35·71		33	10,890	38·92	
16	5,280	36·17		34	11,220	39·08	
17	5,610	36·44					

TABLE No. 2.

Table showing the Observed Velocities at the End of each Plane on the Dalkey Line, and those which would have been obtained had there existed no Loss from Friction of the Piston, Resistance of the Air, &c.

Inclination.	Length in Chains.	Experiment No. 7. Train 34·7 tons.			Experiment No. 12. Train 53·5 tons.			Experiment No. 15. Train 53·5 tons.			Experiment No. 16. Train 55·8 tons.			Experiment No. 17. Train 58 tons.			Experiment No. 19. Train 63·2 tons.			Experiment No. 20. Train 64·7 tons.		
		Observed Velocity.	Calculated Velocity.	Difference.	Observed Velocity.	Calculated Velocity.	Difference.	Observed Velocity.	Calculated Velocity.	Difference.	Observed Velocity.	Calculated Velocity.	Difference.	Observed Velocity.	Calculated Velocity.	Difference.	Observed Velocity.	Calculated Velocity.	Difference.	Observed Velocity.	Calculated Velocity.	Difference.
1 in 166	28	20·0	25·5	5·5	17 2	22·3	5·1	15·0	20·6	5·6	12·9	16·8	3·9	15·0	20·4	5·4	13·4	17·2	4.8	12·0	15·6	3·6
1 „ 218	8	21·2	29·5	8·3	20·0	25·3	5·5	16·4	23·8	7·4	13·4	19·8	6·4	16·4	23·6	7·2	14·4	19·8	5·4	13·4	18·7	5·3
1 „ 104	10	22·5	32·7	10·2	20·0	27·8	7·8	19·0	25·4	6·4	13·4	20·9	7·5	17·2	25·3	8·1	15·0	20·8	5·8	12·9	19·5	6·6
1 „ 139	4	22·5	34·2	11·7	20·0	29·0	9·0	17·2	26·3	9·1	14·4	22·0	7·0	17·2	26·5	9·3	13·9	21·4	7·5	13·4	20·2	6·8
1 „ 100	8	25·7	36·3	10·6	21·2	30·5	9·3	18·0	27·4	9·4	13·9	22·7	8·8	17·2	27·4	10·2	14·4	22·1	7·7	13·4	20·8	7·4
1 „ 131	12	25·7	40·3	14·6	24·0	33·8	9·8	19·0	28·8	9·8	15·0	24·8	9·8	18·0	28·6	10·6	15·7	24·2	8·5	15·9	22·4	8·5
1 „ 211	6	27·7	42·4	14·7	24·0	35·6	11·6	20·0	30·3	10·5	15·0	26·1	11·1	18·0	31·2	13·2	15·0	25·0	10·0	13·9	23·0	9·1
1 „ 115	24	30·0	47·8	17·8	27·0	40·2	12·5	24·0	34·4	10·4	20·0	30·0	10·0	21·2	33·4	12·2	15·7	26·0	11·3	18·0	26·5	8·5

TABLE No. 3.

Distances.	No. 1. South Eastern Railway. Weight of Train, 68 tons. Cylinder, 14in. Length of Stroke, 18in. Driving Wheel, 5ft. 6in.			No. 2. South Eastern Railway. Weight of Train, 78 tons. Cylinder 14in. Length of Stroke, 21in. Driving Wheel, 5ft. 6in.			No. 3. South Eastern Railway. Weight of Train, 120 tons. Cylinder 14in. Length of Stroke, 18in. Driving Wheel, 5ft. 6in.			No. 4. South Eastern Railway. Weight of Train, 84 tons. Cylinder, 14in. Length of Stroke, 21in. Driving Wheel, 5ft. 6in.			No. 5. South Eastern Railway. Weight of Train, 72 tons. Cylinder, 14in. Length of Stroke, 18in. Driving Wheel, 5ft. 6in.		
	Inclination.	Time.	Observed Velocity.	Inclination.	Time.	Observed Velocity.	Inclination.	Time.	Observed Velocity.	Inclination.	Time.	Observed Velocity.	Inclination.	Time.	Observed Velocity.
		m. sec.	Miles.		m. sec.	Miles.		m. sec.	Miles.		m. sec.	Miles.		m. sec.	Miles.
Started ...	...	16 0	...	...	7 15	...	...	26 30	10·6	...	2 40	...	...	25	...
¼ Mile ...	Rising 1 in 264	17 15	10·0	Rising 1 in 264	7 50	12·0	Rising 1 in 264	27 / 27 55	20·0	Rising 1 in 264	3 30 / 4 6	12·6	Falling 1 in 264	1 5 / 1 30	18·0
½ „ ...	Do.	18 16	13·6	Do.	8 45	16·3	Do.	29 30	21·4	Do.	4 34 / 4 56	20·5	Do.	50 / 2 8	25·0
¾ „ ...	Do.	19 4	18·8	Do.	9 25	22·5	Do.	30 12	23·6	Do.	5 17 / 5 25	25·0	Do.	24 / 2 39	30·0
1 Mile ...	Do.	19 44	22·5	Do.	10 5	22·5	Do.	30 50	24·3	Do.	51 / 6 8	26·5	Do.	54 / 3 9	31·0
¼ „ ...	Do.	20 20	25·0	Do.	10 40	25·7	Do.	31 27	25·6	Do.	25 / 6 39	32·4	Do.	22 / 3 36	32·1
½ „ ...	Do.	20 53	27·4	Do.	11 13	27·4	Do.	32 2	29·0	Do.	54 / 7 7	34 7	Do.	49 / 4 3	32·1
¾ „ ...	Do.	21 55	29·0	Do.	11 46	27·4	Do.	32 33	29·0	Do.	...	...	...	14 / 4 26	37·0
2 Miles ...	Do.	22 25	30·0	Do.	12 20	26·5	Do.	33 4	29·Q	Do.	...	...	...	37 / 4 49	40·0
¼ „ ...	Do.	22 55	30·0	Do.	12 53	27·4	Do.	...	...	...	...	...	...	...	...
½ „ ...	Do.	23 25	30·0	Do.	13 25	28·1	Do.	...	...	...	...	...	...	...	...
¾ „ ...	Do.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3 Miles ...	Do.	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Distances.	No. 6. Narrow Gauge Engine (Bodmey). Weight of Train, 66 tons. Cylinder, 16in. Stroke, 2ft. 6in. Driving Wheel, 5ft. 6in.			No. 7. Great Western Railway Engine. Weight of Train, 113 tons. Cylinder, 15¾in. Stroke, 20in. Driving Wheel, 7ft.			No. 8. The same Engine and Load returning from Didcot.			No. 9. The same Engine, with a gross Load of 94 tons.			No. 10. Grand Junction Railway Engine. Weight of Train, 117 tons. Cylinder, 14¼in. Stroke, 20in. Driving Wheel, 6ft.		
	Inclination.	Time.	Observed Velocity.	Inclination.	Time.	Observed Velocity.	Inclination.	Time.	Observed Velocity.	Inclination.	Time.	Observed Velocity.	Inclination.	Time.	Observed Velocity.
		m. sec.	Miles.		m. sec.	Miles.		m. sec.	Miles.		m. sec.	Miles.		m. sec.	Miles.
Started ...	...	11 0	...	...	1 11	...	...	...	...	...	7 10	...	...	...	...
¼ Mile ...	Rising 1 in 264	12 2	16·6	Nearly level	2 40	13·1	Nearly level.	...	...	Nearly level	8 0	18·0	Falling 1 in 300	...	12·5
½ „ ...	Do.	12 40	28·0	Do.	3 49	25·0	Do.	...	14·0	Do.	40	22·5	Do.	...	19·1
¾ „ ...	Do.	13 10	32·1	Do.	4 25	28·1	Do.	...	25·6	Do.	9 12	28·1	Do.	...	24·3
1 Mile ...	Do.	13 40	32·1	Do.	57	33·3	Do.	7 15	30·0	Do.	40	32·1	Do.	...	27·3
¼ „ ...	Do.	14 7	33·5	Do.	5 24	33·25	Do.	42	33·3	Do.	10 5	36·0	Do.	...	30·0
½ „ ...	Do.	...	33·5	Do.	6 0	33·31	Do.	8 5	40·9	Do.	29	39·2	Do.	...	31·0
¾ „ ...	Do.	...	...	Do.	29	34·6	Do.	27	40·9	Do.	52	37·5	Do.	...	34·6
2 Miles...	Do.	...	...	Do.	55	34·6	Do.	47	45·0	Do.	11 12	45·0	Do.	...	34·6
¼ „ ...	Do.	...	...	Do.	7 21	36·0	Do.	9 8	42·8	Do.	33	42·8	Do.	...	36·0
½ „ ...	Do.	...	...	Do.	46	41·0	Do.	27	47·4	Do.	54	42·8	Do.	...	36·0
¾ „ ...	Do.	...	...	Do.	8 8	42·9	Do.	46	47·4	Do.	12 13	47·3	Do.	...	37·5
3 Miles...	Do.	...	...	Do.	29	41·0	Do.	10 4	50·0	Do.	32	47·3	Do.	...	36·0
¼ „ ...	Do.	...	...	Do.	51	45·0	Do.	21	53·0	Do.	51	47·3	Do.	...	...
½ „ ...	Do.	...	...	Do.	9 11	45·0	Do.	38	53·0	Do.	13 9	50·0	Do.	...	...
¾ „ ...	Do.	...	...	Do.	31	45·0	Do.	55	53·0	Do.	27	50·0	Do.	...	...
4 Miles...	Do.	...	...	Do.	51	47·4	Do.	11 12	53·0	Do.	45	50·0	Do.	...	...
¼ „ ...	Do.	...	...	Do.	10 10	47·4	Do.	29	53·0	Do.	14 1	56·3	Do.	...	...
½ „ ...	Do.	...	...	Do.	29	...	Do.	46	53·0	Do.	...	...	Do.	...	...
¾ „ ...	Do.	...	...	Do.	11 6	49·0	Do.	12 2	56·0	Do.	...	...	Do.	...	...
5 Miles...	Do.	...	...	Do.	25	...	Do.	19	60·0	Do.	...	...	Do.	...	...

The carriages were started from rest at 50 chains up the incline, and the following results were obtained from numerous experiments:—

EXPERIMENTS ON THE FRICTION OF WAGGONS.

Number of the Experiments.	Date of the Experiments.	Description of the Trains.	Weight of the Train.	Weight per Waggon.	Distance run over.	Duration of the Race.	Difference of Level.	Friction.	Friction per ton.	Observations.
	1863.		Tons.	Tons.	Feet.	Min. Sec.	Feet.		Lbs.	
VI.	July 29 ...	1 empty waggon	...	1·85	6204	...	36·78	$\frac{1}{169}$	13·28	This waggon has only a platform surrounded by an open railing.
VIII.	July 30 ...	1 tender	...	4·50	5967	...	36·66	$\frac{1}{163}$	13·76	
III.	July 29 ...	1 loaded waggon	...	4·65	7326	...	37·16	$\frac{1}{197}$	11·36	This form gives a great hold on the air
IV.	July 29 ...	1 loaded waggon	...	5·15	6663	...	36·95	$\frac{1}{180}$	12·42	
V.	July 29 ...	1 loaded waggon	...	5·20	7455	...	37·19	$\frac{1}{200}$	11·17	An axle-box, very hot in driving.
IX.	July 31 ...	1 tender	...	5·50	7266	...	32·88	$\frac{1}{221}$	10·13	
II.	July 29 ...	5 loaded waggons	25·58	5·12	9324	10 20	38·19	$\frac{1}{244}$	9·17	
I.	July 29 ...	5 loaded waggons	31·31	6·26	9933	10 00	38·55	$\frac{1}{258}$	8·69	
XI.	Aug. 1 ...	{10 loaded waggons, 1 tender (11 carriages)}	48·72	4·43	10008	11 45	38·58	$\frac{1}{259}$	8·64	
X.	July 31 ...	14 loaded waggons	61·65	4·40	9579	...	35·32	$\frac{1}{271}$	8·26	
VII.	July 30 ...	19 loaded waggons	92·00	4·84	10723	11 00	38·85	$\frac{1}{276}$	8·11	
XII.	Aug. 1 ...	{24 loaded waggons, 1 tender (25 carriages)}	110·00	4·40	10668	...	38·82	$\frac{1}{275}$	8·15	
XV.	Aug. 15 ...	{7 waggons, 1 tender, & 1 engine in front ...}	40·59	4·00	8175	8 30	37·35	$\frac{1}{219}$	10·23	Including the friction of the engine.
XIII.	Aug. 2 ...	{17 waggons, 1 tender, and 1 engine ....}	94·96	4·78	11262	...	39·10	$\frac{1}{288}$	7·78	Including the friction of the engine.
XIV.	Aug. 2 ...	{20 waggons, 1 tender, and 1 engine ....}	110·14	4·83	10911	12 10	38·75	$\frac{1}{282}$	7·96	Including the friction of the engine.

By the examination of the Table, it will be seen that the trains which, on the average, did not obtain a velocity from gravity exceeding 28 miles, ran on the level before they came to a state of rest, from 4,875ft. to 7,962ft., and thus, on the average, run above one mile and a quarter from their own vis viva alone.

The friction per ton, indicated by these results, varied from 13·76lbs., with a single tender, to 7·78lbs. with a heavy train, and with an average train may be called 9lbs.

The traction of passenger carriages may possibly exceed this, from the greater resistance of the air, but as both carriages and permanent way are now better constructed than at the period these experiments were made, it is probable that 9lbs. fairly represents the friction of passenger carriages, at a speed not exceeding 30 miles. I have, however, as it is proposed to propel carriages on my principle to a greater speed than 30 miles, assumed, in order to be on the safe side, 15lbs. per ton, with a maximum propelling velocity of 45 miles per hour, which is consistent with the experiment of the British Association and Gauge Commissioners.

With the traction, the rate of retardation will be indicated by the following table:—

2 miles	47
$1\frac{3}{4}$ "	43·54
$1\frac{1}{2}$ "	40·68
$1\frac{1}{4}$ "	37·14
1 "	33·2
$\frac{3}{4}$ "	28·6
$\frac{1}{2}$ "	23·2
$\frac{1}{4}$ "	16·6
0 Rest.	

Having thus obtained the rate of decrease of speed which will occur when the propelling power ceases to act, the effect of more rapidly overcoming the vis inertiæ of the train may be explained by reference to Table No. 1 of the acceleration of trains with varying tractive power, and also by some models which will be exhibited at the meeting.

It will be then seen that the velocity acquired by a train of 200 tons, propelled by a tractive force of 2,000lbs., would be 11,832 miles in one mile, and that if a tractive force of 4,000lbs. is applied to the same train it will attain a velocity of 29·15 miles at the end of half a mile, which velocity, it appears from Pambour's experiments, would carry it by its own vis viva the second half mile, and the journey will be performed in less than half the time by employing double tractive power on half the distance.

To take another case, the train of 200 tons would obtain a velocity of 16·8, at the end of two miles, with a tractive force of 2,000, but if a tractive force of 8,000 is applied, the velocity will be 17 miles, at the end of one mile, and if left to travel of its own vis viva will still have a velocity of 33 miles at the end of the second mile, and, therefore, three times the average speed will be obtained by applying four times the tractive power for half the distance.

Numerous instances may be given, but it must be evident that economy of power is obtained by overcoming the vis inertiæ more rapidly, and this result is fully illustrated by the undulating railway principle.

When velocity is obtained by inclines descending each way, from each station, the economy of this arrangement is admitted, but it cannot be practically carried out, because the gradients are governed by the levels of the country.

By the use of a horizontal propeller the practical advantage of the undulating system is obtained as an auxilliary, as well as the sole motive power, and the advantage of such propeller will be specially felt at stations situated at the foot of inclines where much time is now frequently lost in starting trains.

The economy of avoiding the use of locomotive and using local propelling powers is evident, especially in underground railways, that it is scarcely necessary to call attention to it.

The speed and comfort will be increased, and the reduction in cost will be so great that it is safe to assume that the greater part of the present cost of locomotives will be saved, because the Stationary Hydraulic Propeller System will require a much reduced outlay of capital, and will avoid the main cause of the destruction of the permanent way. It will also be more agreeable to the public, because the passengers will travel faster, and the residents in the neighbourhood will avoid much noise and vibration.

The only arguments that can arise against the adoption of this system must be that there are objections equally important against its use. The only one yet suggested is that the train will be helpless from want of propelling power in the event of being signalled to come to a stop between the stations, but this is an unimportant objection when stations are frequent, and no stoppage would ever occur from want of power, because it is intended always to have sufficient vis viva to propel the train about half a mile beyond the station it is intended to stop at.

The main cause of such stoppages will be removed when the locomotive is removed, and it is quite easy in practice to stop the train at one station until the line is reported clear to the next; besides which the use of stationary propelling power does not prevent locomotive power being used as an auxiliary in case of an accident, and by using hydraulic pressure, propellers of small power may be laid down at little cost, and various points in every terminal station, and will be always useful for the shifting and arranging of trains.

The average amount of tractive power proposed to be used is 8 tons (or about equal to three locomotives), which acting over a length of 300ft. will give a velocity of 34·3 miles to a train of 60 tons, and an amount of vis viva sufficient to carry it one mile and a quarter on the level. 34·3 miles is the velocity due to a fall of 39ft., or a height of 66ft. It would run a gradient of 1 in 240, or a height of 22ft.; or that which a train would acquire in running one mile down an incline of 1 in 80. If there is a difference of height against the train, it will have to be added to the 39ft.—that is, the velocity given must be that of a body falling 39ft. + the height of the next station or − the fall. Thus, if the rise between the two stations was 50ft. the velocity required in the train would be 52 miles per hour, which is quite practical, and, therefore, no gradient on a metropolitan line would affect the application of the principle. As there is no difficulty in running a speed of 60 miles on a railway, a train may be propelled from a station a distance of three and four miles on the level. The velocity of 60 miles is that due to a fall of 130 or on a plane of 1 in 90 for four miles.

As the average distance of the stations on the metropolitan lines is not above three quarters of a mile, the time consumed between them will not exceed two minutes on the level, the average velocity being about 25 miles per hour.

The amount of stationary power constantly at work required at each station will be as follows, assuming trains to be dispatched every five minutes.

2,240 × 8 = 17,920lbs. has to be raised 300ft. in five minutes, or 60ft. in one

minute. $\frac{17{,}920 \times 60}{33{,}000} = 33$ horse-power. Allowing 40 per cent. loss from the hydraulic or other application, 46 horse-power will be required at each station, or not more than 15, commercial horse engine to each line, or a total of 30 horse-power commercial for each station, the cost of working which will not exceed £1 per day.

The weight assumed of 60 tons for metropolitan railway trains may be somewhat under the average, but there is no case when they are dispatched every five minutes, as assumed in my calculations. There is, however, no difficulty in increasing the propelling power if necessary, nor any difficulty in running trains every two or three minutes, if the traffic requires it.

The paper which I have now the honour to lay before the Section is not so complete as I should have desired it, if more time could have been given to make further experiments, and to give a detailed drawing of the apparatus. At the same time the subject is of so much importance, as we have sufficient facts to leave no doubt of the mechanical results, I trust the Paper will be entitled to your consideration, and to form a proper subject for discussion.

ECONOMY IN THE USE OF STEAM.

By D. M. Greene, C.E., Second Assist. Eng. U.S.N.

(From the Journal of the Franklin Institute.)

(*Continued from page* 225.)

Absolute available Work, in a Unit of Steam or Water, for any Measure of Expansion.

Let W_1 = the total work.

W = as before, the work due to a unit of steam, when used without expansion (2).

r = ratio of work theoretically due to a unit of steam, when used with any measure of expansion, to that done when the same steam is used without expansion—according to the theory as usually applied.

c_1 = loss due to clearance (7).

b = loss due to "blowing out."

Then retaining the previous notation we evidently have

$$W_1 = W\, r\, [(1 - c_1)\,(1 - b)]. \qquad (8)$$

in which

$$r = 1 + \text{hyp. log. } \frac{l}{a}$$

Substituting now this value, together with that of c_1 already found (7) in (8), we get

$$W_1 = W\left[1 - \left[\frac{c}{a+c} - \frac{\left(\text{hyp. log.}\frac{l+c}{a+c} - \frac{a \text{ hyp. log. } \frac{l}{a}}{a+c}\right)}{1 + \text{hyp. log. } \frac{l}{a}}\right]\right] \times \left(1 + \text{hyp. log. } \frac{l}{a}\right)(1-b)$$

$$= W\left[\frac{a\left(1 + \text{hyp. log. } \frac{l}{a}\right)}{a+c} + \text{hyp. log. } \frac{l+c}{a+c} - \frac{a \text{ hyp. log. } \frac{l}{a}}{a+c}\right][1-b]$$

$$= W\left[\frac{a}{a+c} + \text{hyp. log. } \frac{l+c}{a+c}\right][1-b] \qquad (9)$$

The above expression would give the absolute work done by the steam, were it not for the fact that there is a loss of pressure between the boiler and the cylinder; that is, the initial cylinder pressure is always less than the boiler pressure; the difference being generally about three per cent. of the boiler pressure; although sometimes greater and sometimes slightly less. Hence if p be the boiler pressure above zero, in pounds, the initial cylinder pressure will be only $\cdot 97 p$; while the average pressure during the stroke will be (4), without clearance,

$$\cdot 97\, p . \frac{a}{l}\left[1 + \text{hyp. log. } \frac{l}{2}\right] \qquad (9^a)$$

or the work actually done will be ·97 of that due to the steam made in the boilers and (9) becomes

$$W_1 = \cdot 97\, W\left[\frac{a}{a+c} + \text{hyp. log. } \frac{l+c}{a+c}\right][1 - b.] \qquad (10)$$

The reciprocal of this, or $\frac{1}{W_1}$ will give the cost (C) of a horse-power per hour, in pounds of water evaporated, thus;

$$C = \frac{1}{97\, W\left[\frac{a}{a+c} + \text{hyp. log. } \frac{l+c}{a+c}\right][1-b]} \qquad (11)$$

But our object is to determine the net, or *effective* dynamic value of a unit of water—the surplus after deducting the constant prejudicial resistances of back-pressure, and the pressure due to the friction of the engine itself; which we will represent by v and f, respectively.

To correct the absolute dynamic value given by (9), it is only necessary to multiply that value by that fraction which expresses the value of the average effective pressure above zero, in terms of the boiler pressure: this value will obviously be (9^a.)

$$\frac{\cdot 97\, p\, \frac{a}{l}\left[1 + \text{hyp. log. } \frac{l}{a}\right] - [v - f]}{p}$$

which multiplied by (9) gives for the net effective dynamical value $W_1{}^1$ of a pound of water,

$$W'_1 = \frac{W\left[\frac{a}{a+c} + \text{hyp. log.}\frac{l+c}{a+c}\right]\left[\cdot 97\, p\frac{a}{l}\left(1 + \text{hyp. log.}\frac{l}{a}\right) - (v+f)\right][1-b]}{p} \qquad (12)$$

whence finally for the cost (C_1) of a net effective horse-power, we get

$$C_1 = \frac{1}{W_1{}^1};$$

or

$$C = \frac{p}{W\left[\frac{a}{a+c} + \text{hyp. log.}\frac{l+c}{a+c}\right]\left[\cdot 97\, p\frac{a}{l}\left(1 + \text{hyp. log.}\frac{l}{a}\right) - (v+f)\right][1-b]} \qquad (13)$$

An inspection of (13)—observing the manner in which p enters in both numerator and denominator—shows us that the value of C will be diminished by increasing p; by diminishing c, v, f, and b; and also that the slight increase of W, due to the increase of p, has the same tendency in a very slight degree.

We are now prepared to apply the formula to a practical

Example.—In the engines of the *Michigan*, under the conditions of the "Erie Experiments," $l = 96''$; $c = 5''57$; $v + f = 2\cdot 7 + 2\cdot 1 = 4\cdot 8$.; $p = 21 + 14\cdot 7 = 35\cdot 7$; and $\cdot 97\, p = 34\cdot 63$. To determine the cost of a net horse-power in pounds of water, when the steam is cut off at $\frac{4}{10}$ of the stroke from the beginning.

Making, for simplicity, $l = 100$, c becomes 5·8, and $a = 40$; then, putting $b = 0$, for fresh water, (13) becomes

$$C = \frac{35\cdot 7}{\cdot 026\left[\frac{40}{45\cdot 8} + \text{hyp. log. } \frac{105\cdot 8}{45\cdot 8}\right]\left[34\cdot 66 \times \cdot 4\left(1 + \text{hyp. log. } \frac{100}{40}\right) - 4\cdot 8\right]}$$

$$= \frac{35\cdot 7}{\cdot 026\,(\cdot 873 \times \cdot 837)\,[34\cdot 66 \times \cdot 4\,(1 + \cdot 916) - 4\cdot 8]}$$

$$= \frac{35\cdot 7}{\cdot 026 \times 1\cdot 71 \times 21\cdot 76} = \frac{35\cdot 7}{\cdot 967} = 36\cdot 92 \text{ pounds.} \qquad (14)$$

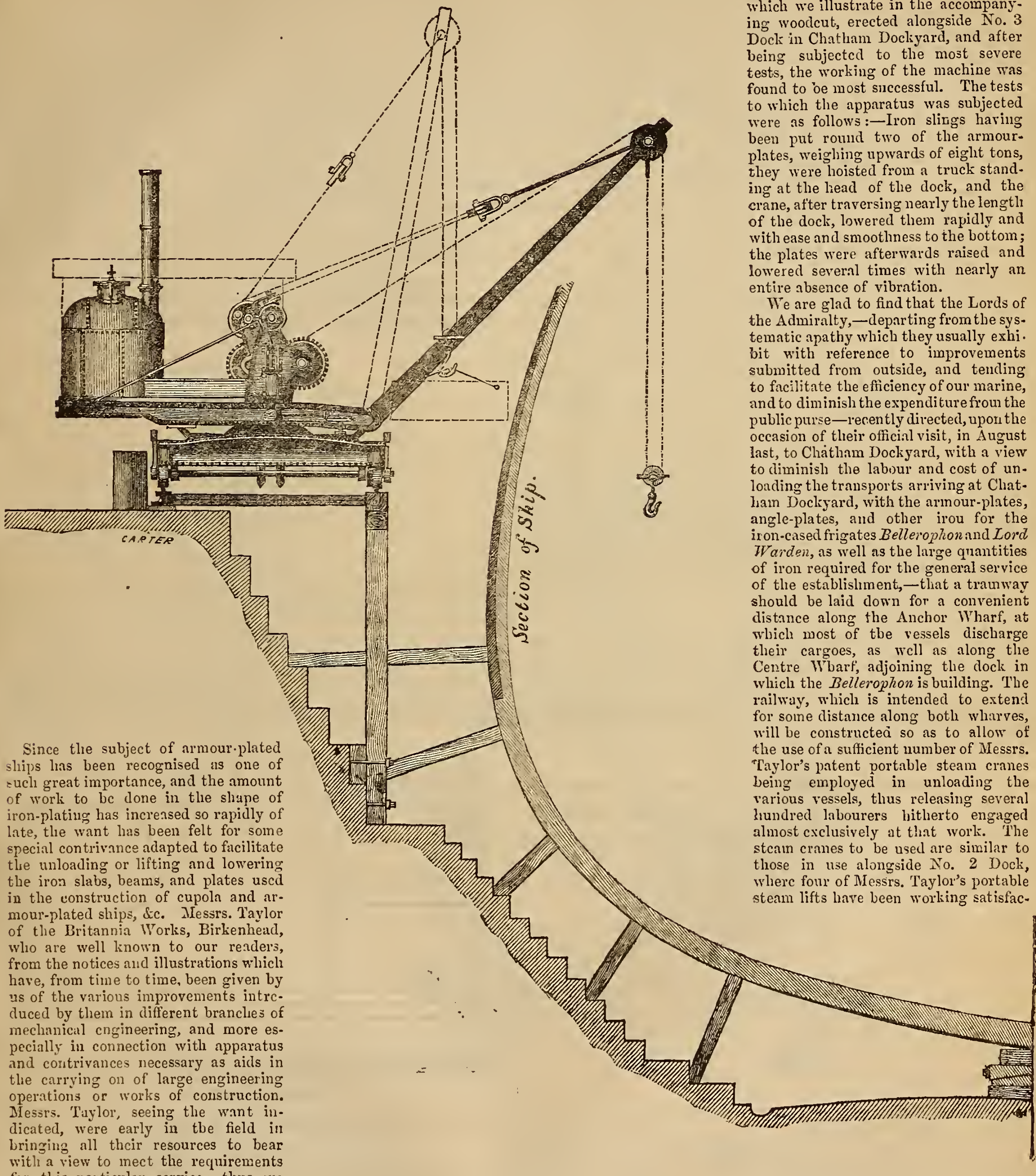
In the "Erie Experiments," the cost, when cutting off at $\frac{4}{9}$, was found to be 36·235lbs.

Thus, in effect, the following Table embracing the conditions of the "Erie Experiments" with different pressures has been constructed; the steam under each of the assumed conditions of pressure, has been supposed to be cut off successively at $\frac{1}{10}, \frac{2}{10}, \frac{3}{10} \ldots \frac{10}{10}$ of the stroke, from the beginning.

Cut-off.	Cost of a Net Horse-power per hour in Pounds of Water.					
	p = 2·43 Atmos. = 35·7lbs.	p = 3 Atmos. = 44·1lbs.	p = 4 Atmos. = 58·8lbs.	p = 5 Atmos. = 73·5lbs.	p = 6 Atmos. = 88·2lbs.	p = 9 Atmos. = 132·3lbs.
$\frac{1}{10}$	81·21	73·50	67·59	63·91	61·68	57·52
$\frac{2}{10}$	47·35	45·00	42·92	41·52	40·65	38·30
$\frac{3}{10}$	39·53	37·60	36·52	35·51	34·64	33·08
$\frac{4}{10}$	36·96	35·57	34·39	33·56	32·91	31·45
$\frac{5}{10}$	36·50	35·28	34·19	33·26	32·55	31·28
$\frac{6}{10}$	37·26	36·15	35·21	34·51	33·66	32·11
$\frac{7}{10}$	38·89	37·69	36·52	35·68	35·42	33·57
$\frac{8}{10}$	41·85	40·09	39·20	37·79	37·53	36·05
$\frac{9}{10}$	44·63	43·58	42·00	41·06	40·46	38·91
$\frac{10}{10}$	51·16	46·91	45·94	45·09	40·10	42·27

(*To be continued.*)

J. TAYLOR & Co's. PATENT LOCOMOTIVE STEAM CRANE.



Since the subject of armour-plated ships has been recognised as one of such great importance, and the amount of work to be done in the shape of iron-plating has increased so rapidly of late, the want has been felt for some special contrivance adapted to facilitate the unloading or lifting and lowering the iron slabs, beams, and plates used in the construction of cupola and armour-plated ships, &c. Messrs. Taylor of the Britannia Works, Birkenhead, who are well known to our readers, from the notices and illustrations which have, from time to time, been given by us of the various improvements introduced by them in different branches of mechanical engineering, and more especially in connection with apparatus and contrivances necessary as aids in the carrying on of large engineering operations or works of construction. Messrs. Taylor, seeing the want indicated, were early in the field in bringing all their resources to bear with a view to meet the requirements for this particular service: thus we find that in August, 1862, for the purpose of facilitating the plating of the iron-clad frigate *Royal Oak*, Messrs. Taylor had succeeded in getting one of their Patent Steam Travelling Cranes, which we illustrate in the accompanying woodcut, erected alongside No. 3 Dock in Chatham Dockyard, and after being subjected to the most severe tests, the working of the machine was found to be most successful. The tests to which the apparatus was subjected were as follows:—Iron slings having been put round two of the armour-plates, weighing upwards of eight tons, they were hoisted from a truck standing at the head of the dock, and the crane, after traversing nearly the length of the dock, lowered them rapidly and with ease and smoothness to the bottom; the plates were afterwards raised and lowered several times with nearly an entire absence of vibration.

We are glad to find that the Lords of the Admiralty,—departing from the systematic apathy which they usually exhibit with reference to improvements submitted from outside, and tending to facilitate the efficiency of our marine, and to diminish the expenditure from the public purse—recently directed, upon the occasion of their official visit, in August last, to Chàtham Dockyard, with a view to diminish the labour and cost of unloading the transports arriving at Chatham Dockyard, with the armour-plates, angle-plates, and other iron for the iron-cased frigates *Bellerophon* and *Lord Warden*, as well as the large quantities of iron required for the general service of the establishment,—that a tramway should be laid down for a convenient distance along the Anchor Wharf, at which most of the vessels discharge their cargoes, as well as along the Centre Wharf, adjoining the dock in which the *Bellerophon* is building. The railway, which is intended to extend for some distance along both wharves, will be constructed so as to allow of the use of a sufficient number of Messrs. Taylor's patent portable steam cranes being employed in unloading the various vessels, thus releasing several hundred labourers hitherto engaged almost exclusively at that work. The steam cranes to be used are similar to those in use alongside No. 2 Dock, where four of Messrs. Taylor's portable steam lifts have been working satisfactorily about three years past, all the iron used in the construction of the *Achilles* and the plating of the iron-clad frigate *Royal Oak* having been raised and fixed by these means.

FUND FOR THE WIDOW AND FAMILY OF THE LATE WILLIAM TEMPLETON.

It will be in the recollection of our readers that, some twelve months since, an appeal was made through the columns of The Artizan and other scientific journals in behalf of the aged and destitute widow of the well-known author of numerous mechanical works—William Templeton. That appeal, we are sorry to say, was not responded to in a manner at all commensurate with the exigencies of the family whose interests it was intended to promote, nor with the posthumous claims of the talented deceased upon the generosity of mechanical men. The total amount of the subscriptions forwarded to the Templeton Fund Committee was indeed lamentably small, and Mrs. Templeton and her daughters have subsequently had to contend with difficulties, and to endure privations which ought never to have been allowed to fall to their lot.

It is not necessary to recapitulate the literary labours of poor Templeton, nor to descant upon their value. Employers and employed in connection with the engineering trade, both at home and abroad, are alike cognisant of the useful nature of the works which emanated from his pen, and all have mentally and materially benefitted by them. It seems incredible, under these circumstances, that Templeton's family should be permitted to suffer the dreadful evils of penury. Booksellers absorbed the bulk of the profits arising from the sale of the mechanical guide-books of the unfortunate writer, and engineering masters and workmen are apparently equally callous as to the sufferings of his bereaved wife and children. There is yet time, however, to make atonement, and "a message from across the sea" which has been sent us for publication, and for which we willingly allow space, is highly suggestive of the manner in which that atonement should be made. We refer to the subjoined letter from the island of Java. It requires no further remark to recommend it to the notice of the readers of The Artizan:—

"Sourabaya, Java, August 26th, 1864.

"To Joseph Newton, Esq., of the Royal Mint, Tower Hill, London, President of the London Association of Foreman Engineers.

"Sir,—We, the undersigned director and officers of the Java Mail Steam Navigation Company, along with a few others, having learned through the medium of The Artizan, January month, to our great regret, that Mr. William Templeton (the author of so many well-known works, and a man who had done much in his time to diffuse knowledge, and thus to improve the social position of mechanical engineers) was no more, beg to send the enclosed cheque for forty-eight pounds sterling, requesting that you will present it in our name to his widow, whom, we have heard, has been left in rather straitened circumstances, and to assure her at the same time of our sympathy for the loss of her husband, whom many of us had known personally and appreciated.

"Trusting that you will do us this favour, and acknowledge the receipt of this letter in an early number of The Artizan.

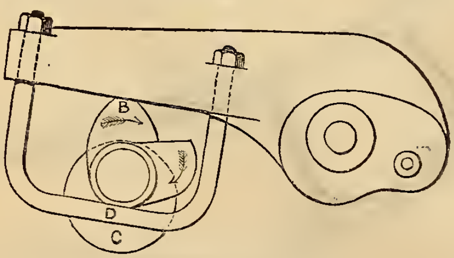
"We remain, Sir, yours most respectfully,

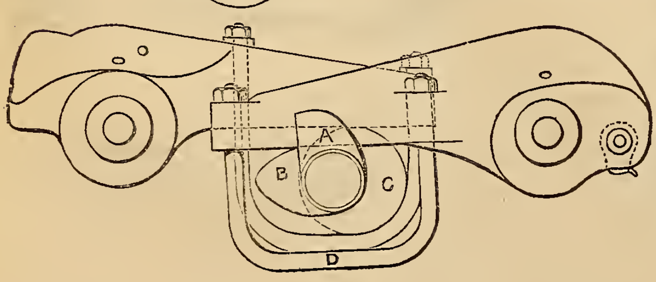
"W. Cores de Vries, Chief Director of the Mail Company; F. H. Schmidt, P.P.C. of the above Company; W. Walker, Superintendent Engineer; J. Johnstone, Chief Engineer; H. T. Still, Chief Engineer; P. W. Van der Veen, Chief Officer; J. Laurie, Chief Engineer; H. Ketjen, Chief Officer; H. J. Mulholland, Chief Engineer; G. C. Valker, Second Engineer; H. Honeman, Third Engineer; R. A. Fawcett, Chief Engineer; A. Mowatt, Chief Engineer; F. Booth, Engineer on Sugar Estate; E. Arundel, ditto; A. Smith, ditto; J. Dixon, ditto; E. Keasbury ditto; W. Gill, ditto; J. Gill, ditto; C. Gill, jun., Master Engineer; J. G. Cook, Managing Engineer for — Buyers, Esq."

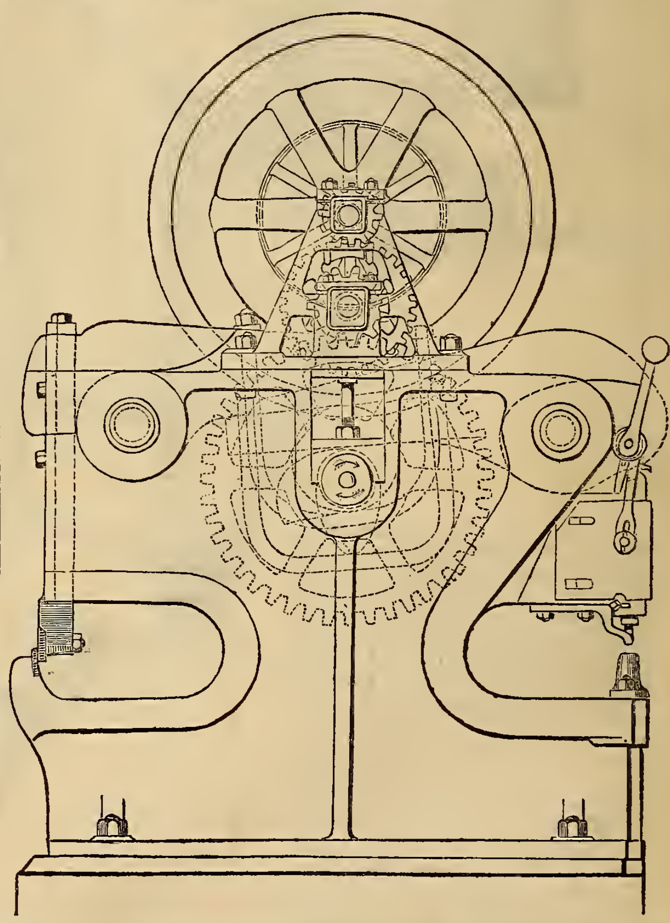
CAMERON'S PATENT DOUBLE CAM LEVER PUNCHING MACHINE

Mr. Cameron, of the Egerton-street Ironworks, Hulme, Manchester, has sought by his invention to remove the practical objections which have been advanced against lever punching machines, worked by a single cam, viz., their bulk, consequent on the great length of lever necessary to withdraw the punch from the hole it has perforated, by their weight and leverage, and which is not always sufficient for that purpose, when the punch is not properly made, or worn—the lever in this case being held up, and the working of the machine stopped. Mr. Cameron, in his improved lever punching machine, which we here illustrate, appears to us to have designed a very simple and efficient mode of removing those objectionable features. The main shaft is fitted with a second or double cam, A, which serves to withdraw the punch with certainty from the hole it has perforated, and so insure the continuous working of the machine. After the lever has been raised by the ordinary cam B, and the hole punched, the second, or double cam, A, in the course of its revolution comes in contact with the wrought-iron strap, D, attached to the lever, and draws it down, and also the punch from the hole. This arrangement allows of short levers being employed, the gearing being contained within the machine, which is thus made very compact.

We understand that Mr. Cameron's punching machine is working satisfactorily at yards near Liverpool, and, amongst other places, at Messrs. Jones, Quiggin, and Co., where the machine under notice works at the rate of twenty-four holes per minute, whilst eighteen holes per minute is considered to be a very good result for the crank or eccentric description of machine.







CORRESPONDENCE.

We cannot hold ourselves responsible for the opinions of our Correspondents.

THE LATE WILLIAM TEMPLETON.

To the Editor of The Artizan.

Sir,—I have just heard of the handsome subscription received by Mr. Newton from twenty-two noble fellows at Java, in favour of the widow of poor Templeton. Let us hope that so splendid an effort to relieve the afflicted lady may yet invoke a like spirit among the thousands of his *confrères* at home, and thus secure for her a small annuity in remembrance of him who, although he made many rich, conferred no such blessing on himself.

Yours, &c.,

Tower Hill, Oct. 26th. R. P.

IMPROVEMENTS IN FURNACES FOR COAL-BURNING.

To the Editor of THE ARTIZAN.

SIR,—The following is a plan of movable fire-bars for the furnaces of locomotive and other engines I have designed for burning the coal lately discovered in the Salt Range, India, and which, when consumed in the ordinary locomotive furnaces, is found to clinker in running long distances.

The arrangement consists, as shown in the accompanying woodcuts, of raising every alternate fire-bar about three inches or so above that of the stationary one, at the same end, every alternate fire-bar being hung on the bolts AA, the ends of which are carried by the brackets BB, which are bolted to the sides of the fire-boxes as represented.

The movement for raising the bars is given by the endless screw C on the trailing-wheel shaft of the locomotive, which works into the screw spur-wheel D, on the under side of which there is a spiral thread which gears into the spur-wheel E, giving motion to the shaft F, on which the eccentrics GGGG are keyed, which through the eccentric rods work the rocking-shafts HH, on the levers of which the fire-bars rest. The amount of throw can be regulated by shifting the pin in the slotted link.

By this description of gearing, the high velocity of the trailing-wheel shaft can be reduced to that considered to be necessary for the movement of the fire-bars to prevent clinkers forming upon them.

It is not intended that the motion should go on continuously while running, but to be thrown off or on, as may be required, by giving a few turns to the hand-wheel I, which acts upon the crank lever J, and disengages the friction clutch K, when the action stops. As this would be a considerable strain or weight on the bolts BB, which carry the fine bars, another bracket could be introduced in the centre of the fire box to carry the weight.

The bars in the woodcuts are represented as resting on the levers of the rocking shaft: they might be attached to them if it was found they did not fall, but it is supposed that the weight of them, as also that of the coal upon them, will be sufficient to cause them to fall into position in the return.

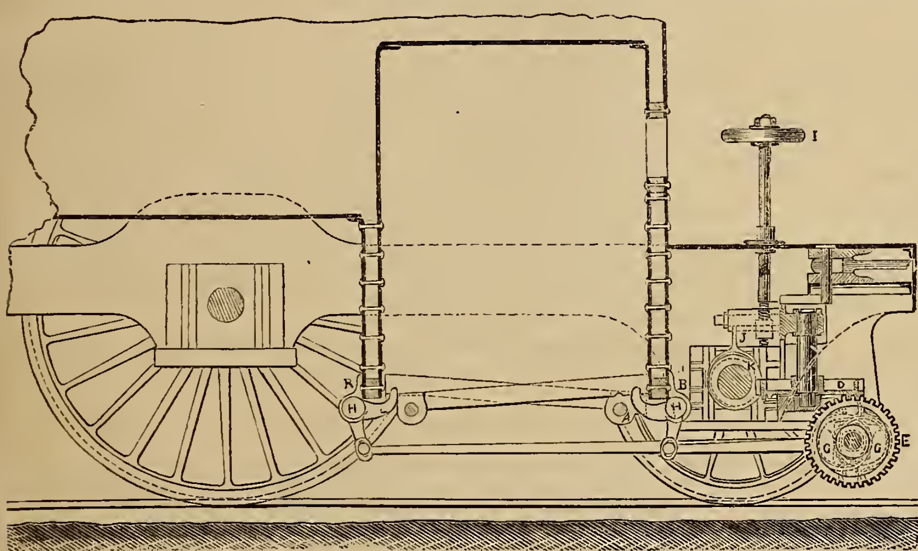
The arrangement of brackets for carrying the gearing, &c., would depend upon the description of locomotive; but, generally speaking, there is sufficient room underneath the foot plate of ordinary locomotives to allow of all the gearing being arranged, as shown in the illustrations.

Yours truly,

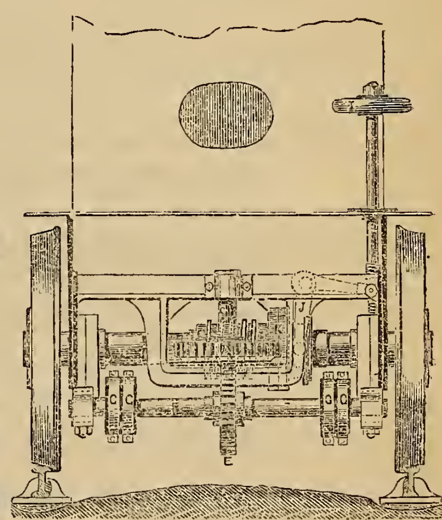
J. L. WATSON, D.P.W.,

Canal Punjaub, India.

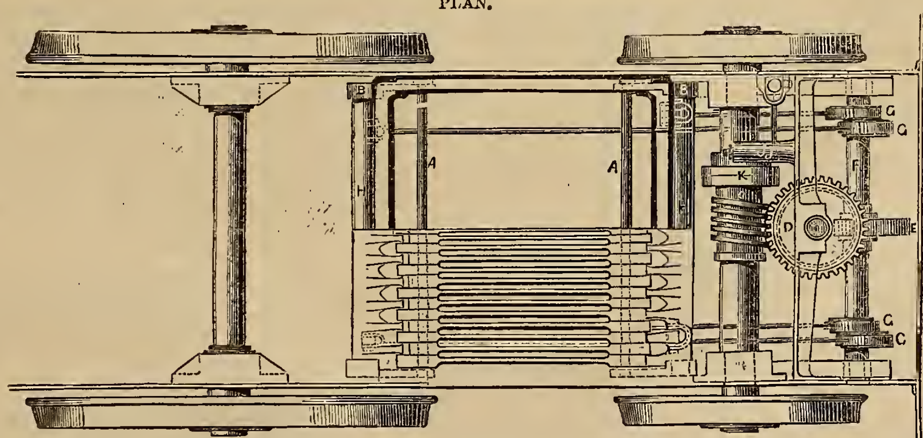
LONGITUDINAL SECTION.



END ELEVATION.



PLAN.



REVIEWS AND NOTICES OF NEW BOOKS.

On the Steam Generating Power of Marine and Locomotive Boilers. By CHARLES WYE WILLIAMS, Esq. London: E. and F. N. Spon.

This is another of Mr. Williams's very useful brochures upon a subject which he has made especially his own, and in connection with which he has a world-wide reputation as an author and practical experimenter.

Although the present work is limited to twenty-five pages of text of about the same size as THE ARTIZAN, and is illustrated with but three woodcuts of boilers and furnaces, the author has treated his subject in five chapters; the first, on the assumed value of tube surface; second, illustrations of the value of face plate surface; third, law for regulating the area of face plate surface; fourth, on steam jets in aid of draught; fifth, on the use of coal in marine and locomotive boilers.

Each division or chapter treats of the subject to which it is devoted in a succinct and practical way.

When dealing with the assumed value of tube-surface, the author, when about to conclude that chapter, adds—"In a word the insufficiency of the tubes as steam generators, has been practically their real protection. Had they transmitted heat sufficient to generate any quantity of steam they would soon have

been destroyed, as no water could have then possibly found its way between them, and where nothing but steam from below would have existed."

"How lamentably erroneous, then, has been the whole system of tubular boilers, and the reference to the tube surface as the measure of the evaporative power of a boiler. The sooner that this fallacy is exposed the better, otherwise we must go on floundering in a mischievous and expensive course of error."

The present addition to Mr. Williams's already-published works on boilers, steam generation, smoke consuming, and other kindred subjects, will be found highly useful by all who are interested in the important question,—the economic generation of steam in marine and locomotive boilers.

Examples of Bridge and Viaduct Construction of Masonry, Timber and Iron. From the contract drawings or admeasurements of select works. By W. Davis Haskoll, C.E. London: Lockwood and Co. 1864.

An excellent selection of examples, more particularly of masonry and timber constructions, very carefully drawn to useful scales of proportion.

The only suggestions we have to make to the author, are first, that he should continue to publish from time to time additional examples in sheets of the same size, and next, accompany them with specifications and details of actual cost.

Packing-case Tables; showing the Number of Superficial Feet in Boxes or Packing-cases, from Six Inches square and upwards. London: Lockwood and Co.

An excellently arranged series of tables, which will be found of great value to merchants, shippers, and shipowners; and we can recommend Mr. Richardson's work to engineers, machinists, and others, to whom it will prove most useful and labour-saving.

NOTICES TO CORRESPONDENTS.

Erratum.—We regret in our Notices to Correspondents in our last month's issue, when referring, in reply to our correspondent, "C. P. D.," to the middle-class express engines of the Brighton Railway, from the designs of Mr. Craven, the locomotive engineer of the company, that gentleman's name was mis-spelt.

C. R.—As we only received your letter shortly before going to press, we are unable in this month's Artizan to give a reply to your queries. We may, however, here state that with reference to the tables of the Committee of the British Association on Steamship Performance to which you refer as having appeared in our pages, these are merely reproduced from the reports of the Committee.

J. C.—The first portion of your communication has received attention, as you will see, in the present number. We will write you by post as to the other subject.

W. E. B.—The reply which we have prepared in answer to your inquiry being necessarily accompanied by illustrations, is too lengthy to allow of our giving insertion to it until our next issue.

Traction.—In reply to your query we cannot do better than refer you to a work upon "The Economy of Steam Power on Common Roads in relation to Agriculturists, Railway Companies, Mine and Coal Owners, Quarry Proprietors, &c.," published by Messrs. Atchley and Co. London: Great Russell-street, Bedford-square.

J. H. (Oldham).—You will find a plate engraving and description of the *Cleopatra* in The Artizan volume for 1859. The particulars you ask, viz., as to the "Rig," are not there given; but we are, through the courtesy of Mr. Scott Russell, enabled to reply as to this. The rig of the *Cleopatra* was a simple two-masted schooner, with Polacca masts, trysails on both; jib and foresail, with yards to set; two square sails on the foremast.

Gas Consumer.—1. Apply to Samuel Hughes, Esq., C.E., Park-street, Westminster, upon the one branch of the subject; and upon the chemical points mentioned, write to Thos. Keates, Esq., F.C.S., Chatham-place, Blackfriars. 2. A very good example of economic management may, we think, be found in the Crystal Palace District Company's Report, and we believe the secretary and manager, Mr. Ohren, will furnish you with some useful information.

L. R. S.—The address of Mr. Richard Dudgeon, the maker of the hydraulic jacks and punches, to which your letter refers, is No. 24, Columbia-street, New York.

India Service (Public Works Department).—The gentleman who has been officially appointed as examiner, and by whom the examination papers for candidates for appointments in the Engineer Establishment have hitherto been prepared, is George Preston White, Esq., C.E.,

R. N.—We are not aware whether Mr. Scott Russell's book has yet been published. Some time ago there was advertised to be published, in three parts, viz., Part 1, Naval Design; Part 2, Practical Shipbuilding; Part 3, Steam Navigation, "The Modern System of Naval Architecture for Commerce and War," by J. Scott Russell, F.R.S., &c.; but whether it has been published, or ever will be published, we do not know. Mr. Russell's address is Great George-street, Westminster, London.

P.—You have been misinformed. The New Floating Bridge at Portsmouth harbour has been fitted with engines by Messrs. James Watt and Co., by whom, we believe, the design for the vessel as modified, as well as the machinery, was supplied. The young gentleman in question was in the employ of the contractors for the hull.

RECENT LEGAL DECISIONS

AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

Under this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

Composition Deeds.—In *re* Brooks it has been decided by the Lord Chancellor that a non-assenting creditor can call upon the Court of Bankruptcy to summon a debtor for the purpose of examining him, to show that the deed is valid; in this respect assenting and non-assenting creditors are on the same footing. The old rule in bankruptcy, refusing to hear against the adjudication a creditor who had not proved, does not furnish a rule by analogy, whereby a non-assenting creditor is to be excluded from the right of examining the debtor against the registration, for in the former case the result of the application, if successful, would have been held to destroy the jurisdiction; whereas in the latter case the result will probably be to establish the jurisdiction of the Court against the deed as an act of bankruptcy. Exceptions to the right of examining the debtor are, where the creditor insists on holding the debtor in prison, or his retaining property for his own exclusive use, which is sought to be recovered by the deed, or his defending an action in which the trustee or the debtor is plaintiff.

Assessment of Gas Companies.—At the Glasgow Appeal Court, the Glasgow Gaslight Company appealed against the valuation of the assessors. Mr. Donaldson stated that the company had been allowed all the deductions which they claimed, with the exception of the depreciation of meters. These deductions reduced the valuation by about £400, leaving the estimated value within the Parliamentary boundary at £20,397. Mr. Allardice, who appeared for the Gas Company, said the ground on which he opposed the valuation was not upon the question regarding the meters, but upon the general principle upon which the valuation was made up. The assessors took as the basis of the valuation the revenue and expenditure of the company. The Gas Company was a company established by Act of Parliament for the manufacture and sale of gas, and was therefore just a manufactory, and should be dealt with in the same way as other manufactories, the profits realised from which were never gone into by the assessors. In support of his argument, Mr. Allardice referred to several cases disposed of under the Poor-law Act. Mr. Donaldson maintained that the practice all over England was to take the revenue into account in estimating the value. Mr. Govan said the Gas Company was a public company, authorised by Act of Parliament to levy rates, which a private company could not do. The Court dismissed the appeal.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

St. Petersburg a Port.—Sir Morton Peto has, it is said, contracted with the Russian Government for the construction of a port at St. Petersburg, which will permit vessels to load and unload there, and make the capital independent of Cronstadt, except for fighting purposes.

Stone-crushing Machine.—This machine, manufactured as Blake's stone-crushing machine, is designed to break stones into fragments, to be used for road-making, railroad ballasting, concrete, or other purposes, and to crush ores or minerals, break flints for crockery-ware, &c. Every revolution of a crank causes the lower end of a movable jaw to advance towards a fixed jaw about a quarter of an inch, and return. Hence, stones dropped in between the convergent faces of the jaws are broken by a succeeding bite, and the fragments then fall lower down and are broken again, and so on until they are made small enough to pass out at the bottom. The distance between the jaws at the bottom limits the size of the fragments, and may be regulated at pleasure. The machine can be made of any size. The usual length of the machines is from 8ft. to 8½ft.; height to top of wheels, 5ft.; width, from 4ft. to 5ft.

Welding by Hydraulic Pressure.—A series of experiments have lately been made at Paris, by M. Duportail, engineer, in the workshops of the Western Railway, to ascertain whether iron might be welded by hydraulic pressure, instead of by the sledge-hammer. The latter, indeed, has not a sufficient impetus to reach the very core of the metal, while continuous pressure acts indefinitely to any depth. In the experiments alluded to, M. Duportail caused two iron bars, 1½in. in diameter, and heated to the welding point, to be placed between the piston and the top of an hydraulic press. The bars were welded together by this means with extraordinary ease, the iron being, as it were, kneaded together, and bulged out at the sides under the pressure. The action of the press was suspended when the part welded was brought down to the thickness of the bars. After cooling, the welded part was cut through, to examine the inside, which was found per-

fectly compact. To try it, one of the halves was placed under a forge-hammer, weighing 1,800 kil., and it was not until the third stroke that the welding was discovered.

Production and Application of Petroleum.—At a recent meeting of the Polytechnic Association of the American Institute, Dr. Rowell exhibited a glass model, illustrating the apparatus recently introduced in the oil region for raising petroleum. By the present mode, after a hole some 4in. or 5in. in diameter is bored through the earth down to the oil, a pipe is introduced with a pump near the bottom, and the oil is thus pumped out. In some cases the pressure of gas upon the surface of the liquid forces the oil nearly up to the surface, and it is in these cases that the new apparatus is employed. A second pipe is introduced into the hole, with its lower end bent upwards, so as to enter the lower end of the first pipe. Air is then forced by an air-pump down through the second pipe into the lower end of the first pipe, and as the bubbles arise along this pipe they so reduce the weight of the liquid column that the pressure of the gas raises it to the surface, and thus a constant flow is secured. Dr. Rowell's apparatus consisted of two glass tubes immersed part of their length in water, with the lower end of one tube bent up and entering the lower end of the other. On blowing into the bent tube, the weight of the aqueous column in the other tube was so reduced by the bubbles of air that the pressure of the water outside of the tube forced the water within the tube to the top, and it overflowed. The President remarked that this plan would require a larger expenditure of power than the pump, as the friction of an air-pump is very great. Dr. Rowell suggested as a counterbalancing consideration that with the pump motion must be imparted at every stroke, not only to the long line of pump-rods, but also to the whole liquid column, while with this air-pump arrangement the flow of oil would be constant. There would, therefore, be less expenditure of power in overcoming inertia. Mr. Page stated that the leather of which his boots were made were curried with petroleum instead of the fish oil usually employed, and that, though a year old, it had shown no signs of cracking. He observed that many leather dealers thought petroleum made the leather tougher than fish oil. In reply to a question, he stated that the average of refining petroleum is about five cents per gallon, besides the loss or shrinkage, and that this ranges from 10 to 40 per cent. With respect to petroleum candles, he remarked that he had compared the candles made of Marietta paraffin with the best sperm candles, and their superiority was very marked. They are just about as hard as lead, and remain perfectly solid and dry in the hottest climates.

Preservation of Wood.—The following method is used in Germany for the preservation of wood:—Mix 40 parts of chalk, 40 of resin, 4 of linseed oil, melting them together in an iron pot; then add 1 part of native oxide of copper, and afterwards, with care, 1 part of sulphuric acid. The mixture is applied while hot to the wood by means of a brush. When dry it forms a varnish as hard as stone.

Substitutes for Indian Ink.—A substance much of the same nature and applicable to the same purposes as Indian ink may be formed in the following manner:—Take of isinglass three ounces; make it into a size by dissolving over the fire in six ounces of soft water. Take then Spanish liquorice one ounce, dissolve it in two ounces of soft water over the fire in another vessel, then grind up on a slab with a heavy muller one ounce of ivory black with the Spanish liquorice mixture. Then add the same to the isinglass size while hot, and stir well together till thoroughly incorporated. Evaporate away the water, and then cast the remaining composition into a leaden mould slightly oiled, or make it up in any other convenient way. This composition will be found quite as good as the genuine article. The isinglass size mixed with the colours work well with the brush. The liquorice renders it easily dissolvable, on the rubbing up, with water, to which the isinglass alone would be somewhat reluctant; it also prevents it cracking and peeling off from the ground on which it is laid. A good Indian ink may be made from the fine soot from the flame of a lamp or candle received and collected by holding a plate over it. Mix this with the size of parchment, and it will be found to give a good deep colour. Burnt rice has been by some considered a principal ingredient in the genuine Indian ink, with the addition of perfumes or other substances not essential to its qualities as an ink.

Wells at Pompeii.—All the wells hitherto discovered in the ruins of Pompeii have been dry. Lately one was found in a house called that of the marble dealer; it is circular, very deep, in good preservation, and contains fresh and limpid water. An analysis of the water has been made by M. de Luca, and communicated to the Academy of Sciences. The atmosphere of the well when discovered was not supportable, owing to the carbonic acid gas. A dog was let down for a few moments, but became nearly suffocated, and was only saved by being drawn up immediately. The workmen could only descend to a certain distance, beyond which their light was extinguished. After the vitiated atmosphere had been replaced by the outer air, a pail was let down, and the water brought up was clear, and of a temperature of 15 degrees centigrade (59 Fahrenheit), while that of the external atmosphere was 18 centigrade (65 Fahrenheit). The water was excellent, but with a slight gaseous taste. On being applied to the test paper a slight alkaline reaction was visible, owing to the carbonate of potash, which could readily be transformed into cream of tartar. In this respect the water is very like that of the well of Grenelle.

Fortifications at Milford.—It is expected that important and extensive works will shortly be commenced at the Stack, Milford, in order to render that rock a valuable addition to the defences of the Pembrokeshire coast. From the commanding position of the Stack, a better site for a fort could not be selected.

National Exhibitions.—The returns of the number of visitors to national institutions give the following results for these 11, which we place according to the extent to which they attract the public:—South Kensington Museum, National Gallery, British Museum, Kew Gardens, Hampton Court Palace, Houses of Parliament, the Tower, Windsor Castle, Museum of Practical Geology, National Portrait Gallery, Soane Museum. In 1861 they were visited by 2,815,445 persons; in 1862, the Exhibition year, by 4,641,770; in 1863, with a sort of reaction in sight-seeing, by only 2,656,773. But the South Kensington Museum and Hampton Court Palace had more visitors in 1863 than in 1861.

Number of Bills of Exchange.—The Inland Revenue returns show that the number of bill stamps used by the public is constantly increasing. In the financial year 1861-62 the number issued from the Stamp-office was 5,397,195, and in the next year, 1862-63, 5,501,498. This is exclusive of foreign bills. 1,795,187 stamps for foreign bills were sold in 1861-62, and 1,961,602 in 1862-63. In this latter year stamps were sold for 6,740 inland bills, and 4,288 foreign, to be drawn for upwards of £4,000 each. There is no return as yet of the number of bill stamps sold in the year 1863-64, but it must be very large, for the stamp duty received for them was more by 15 per cent. than in the year 1862-63.

Liverpool Town Improvements.—At a recent adjourned meeting of the Liverpool Town Council, a scheme was proposed for the formation of a large wholesale vegetable market adjoining the existing hay market, and for improving the approaches thereto, at an estimated cost of £83,000. It was referred back to the Markets' Committee for reconsideration. Other schemes for street improvements in the south end, at a cost of £90,000 were approved.

The International Exhibition at Oporto.—A crystal-palace was commenced at Oporto in 1861, the first stone being laid by his Majesty King Pedro V., and is now nearly finished. It is proposed to hold an international exhibition therein, and Don Fernando, the father of the King, has been placed at the head of the commission for carrying out this intention. It is said that the Exhibition is to open in June next, but this will scarcely afford time for sufficient notice.

Industrial Exhibition in London.—An interesting exhibition was recently inaugurated by Earl Russell at Islington. It appears that the working classes of the north of London recently set on foot a project for establishing an industrial exhibition, which they have carried through with commendable energy and success. The exhibition is a very interesting one, and very comprehensive, embracing furniture, engraving, wood carving, botanical, and entomological specimens, philosophical and mechanical instruments, models, of almost every description, &c. It is also enriched with a valuable collection of specimens of art workmanship from the South Kensington Museum, including the collection occasionally sent round to local schools of art, in which pottery, enamel, and glass specimens occupy a conspicuous place; these being supplemented by some precious loans from the Queen herself, sent from Buckingham Palace and Windsor Castle. The industrial exhibition is divided in the main into two parts, that on the left side of the building consisting of the results of skilled labour, and that on the right of amateur productions. The former include some excellent inlaid work and embossing, for the most part highly creditable to the workmen. In the amateur department there are among a multitude of other objects some capital Shakesperian models; a Nightingale cradle, for the use of wounded or helpless invalids; an alarum, termed an "Early Riser," which besides waking the possessor at any time, will forthwith prepare for him a cup of coffee, &c. Paintings in oil and water colours are sent to Islington by carpenters, paperhangers, clerks, firemen, and provision dealers; architectural models are sent by letter-carriers, maid-servants, and hairdressers, and a hairdresser has even sent some plaster busts and plaster statues. The North London Industrial Exhibition originated in a meeting of some half-a-dozen persons, all belonging to the working classes, at the Lamb and Flag Ragged School, Clerkenwell Green, and from first to last it has been practically independant of external aid. A modest guarantee fund of £350 has been subscribed by a few friends of the movement, including among them Lord Shaftesbury, the Chancellor of the Exchequer, and Miss Burdett Coutts; but the Committee do not anticipate the necessity of calling for any contribution from the subscribers.

Electric Light in Factories.—Professor Seely, of New York, proposes to employ the current generated by an ordinary frictional electric machine, and obtains the light by interrupting the current. He proposes to secure the continuous action of the machine in all weathers by surrounding it with a glass case, and keeping the air within the case dry by means of chloride of calcium or other hygroscopic substance. Professor Seely is now engaged in experiments to ascertain what material will produce the most intense light; and if the apparatus works according to anticipation, a factory in which machinery is employed may be lighted without any additional expense, except the small power required to turn the electrical machines. As, in mills driven by water, there is always a surplus of power during the winter months, the only time when lights are required, there would be no expense for this light except the first cost of the apparatus, which would be quite moderate.

South Wales Coal in the London Market.—Arrangements have been in progress for some time, and are now completed, for giving increased facilities to the South Wales colliery proprietors to send their coal to the London market. This is an important matter for both the London public, the Great Western Company, and the colliery owners of South Wales, and there is every probability that before long the quantity of Welsh coal sent to the London market will be enormously increased. The railway route is much shorter than the sea, and finds a most convenient terminus at Brentford, on the Thames, the principal station on the little Great Western and Brentford line. As evidence of the extent to which the traffic might be developed, it may be mentioned that since the increased facilities referred to have been completed, the quantity of Welsh coal sent over the Great Western and Brentford has more than trebled as compared with the corresponding period of 1863.

Progress of the Post.—The number of letters delivered in London in 1862 was 151,619,000, against 146,629,000 in 1861; in Bath, 3,861,000, against 3,769,000 in 1861; in Birmingham, 11,106,000, against 10,689,000 in 1861; in Bradford, 3,200,000, against 3,064,000 in 1861; in Bristol, 7,185,000, against 9,933,000 in 1861; in Cheltenham, 2,269,000, against 2,265,000 in 1861; in Derby, 3,065,000, against 2,919,000 in 1861; in Exeter, 4,094,000, against 3,926,000 in 1861; in Hull, 3,807,000, against 3,527,000 in 1861; in Leeds, 6,610,000, against 6,466,000 in 1861; in Leicester, 2,546,000, against 2,696,000 in 1861; in Liverpool, 15,364,000, against 14,583,000 in 1861; in Manchester, 18,314,000, against 19,270,000 in 1861; in Newcastle-on-Tyne, 4,001,000, against 3,851,000 in 1861; in Norwich, 3,643,000, against 3,409,000 in 1861; in Nottingham, 3,210,000, against 3,285,000 in 1861; in Plymouth, 2,366,000, against 2,252,000 in 1861; in Portsmouth, 2,477,000 against 2,284,000 in 1861; in Preston, 2,259,000, against 2,325,000 in 1861; in Sheffield 3,886,000, against 3,875,000 in 1861; in Southampton, 3,858,000, against 3,915,000 in 1861; and in York, 3,226,000, against 3,133,000 in 1861.

Gun Cotton.—This substance has again been the subject of interesting experiments which we find described in a paper addressed to the Academy of Sciences by M. de Luca. Gun cotton is decomposed very slowly in the dark, somewhat faster in diffused light, very rapidly when exposed to the sun, and still more so when exposed to a heat of about 50 degrees Centigrade. This spontaneous decomposition passes through four different stages. At first it contracts slowly without losing its primitive form and texture, so that its volume becomes ten times less than its original one. A few days later it becomes soft, and is transformed into a sort of gummy matter which adheres strongly to the fingers, and has no longer any appearance of texture or organisation whatever, even when viewed through the microscope. When this mass has become quite homogeneous, its volume is again reduced by one-half. The third stage, which occurs some considerable time after, instead of producing any further contraction, causes an expansion, so that the substance, reduced as it is to one-nineteenth of its original volume, swells up to the full extent of the latter. In this state it is still gummy, but the mass is porous, and full of cavities like a sponge. During these three stages there is a constant evolution of nitrous vapours, which become much more abundant during the third stage. This evolution of gas gradually diminishes during the fourth stage; the substance slowly loses its gummy quality and yellowish colour, and becomes so friable as to admit of being crushed into powder between one's fingers; it then becomes as white as sugar. It takes at least five months to see all these stages passed through. The sugary substance is very acid, nearly entirely soluble in water, and is composed of glucose, gummy substances, oxalic acid, a little formic acid, and another which M. de Luca thinks is new, and with which for the present he has obtained salts of lead and silver. The glucose contained in this last transformation of gun cotton, has the taste and even the flavour of honey; it quickly reduces the tartrate of copper and potash, and ferments in contact with yeast, producing carbonic acid and alcohol. It appears from M. de Luca's experiments that gun cotton will keep indefinitely in vacuo.

Remarkable Plumb-line Deflection at Cowhythe.—We (*Banffshire Journal*) are able to furnish the following particulars respecting this curious local disturbance of the plumb-line in our neighbourhood, which is now the subject of research, with a view to its being traced to its limit, by a party of Royal Engineers. Early during the present century the headland eastward of Portsoy on Cowhythe was visited by an officer of the Royal Engineers with the zenith sector, constructed for the Ordnance Survey of this country by the celebrated Ramsden; and from the observations made with that instrument to determine the latitude of the trigonometrical station there, it was found that the plumb-line, instead of being vertical, was deflected northward of the zenith and southward of the earth's centre fully nine seconds of angular measure. This extraordinary and unexpected result was viewed with great interest by the scientific world, especially by such as were employed by their respective Governments, in connection with the determination of the

figure of the earth; and, by way of verification, a party of the same corps, some sixteen years back, furnished with a new zenith sector, designed by the present Astronomer Royal, and constructed by Troughton and Sims, visited the same spot. More observations, and to a greater number of stars, resulted in confirming the first or earlier determination; and here the matter rested, merely as a subject of occasional wonder to those concerned, till recently the Russian Engineers, in prosecution of their national survey, came upon a similar anomaly in the neighbourhood of their ancient capital, Moscow. On tracing it to its limit, which they have done in a public spirit and most creditable manner, they concluded that there is a vacuum, or a comparative vacuum, of a great many square miles in extent, under the earth's surface in that country. To give some idea of the reasoning which leads to such a startling conclusion, the reader may conceive a wide, deep pit with a plummet suspended from its mouth at the earth's surface. The plumb line will be vertical only when in the centre of the pit, or shaft, it is called in connexion with mines, because it will there be equally attracted in every direction. If carried round the side of the pit, the line will be so deflected from the vertical as to cause all the lines, if produced upwards, to meet in a point above the earth; and such are the phenomena discovered by the geoditical engineers of Russia. The pit, it is true, is closed at its mouth, and no plumb-line can be let down into it; but the spirit level being always at right angles to the plumb-line, discloses the fact as clearly to the mind as the open pit would to the eye. Now, whether the Cowhythe deflection is to be accounted for by a comparative vacuum on the north under the Moray Frith, or by some unknown mass of extraordinary density on the south, or partly by both, is the problem to be solved, and, doubtless, it will be ultimately solved by the thoroughly trained staff of astronomical observers and computers, under their talented chief, Sir H. James. Their present operations with zenith telescopes, transits, chronometers, and theodilites, were commenced at Cowhythe in August, and are now extended southward to the Fourman Hill, near Rothiemay and Westerfield (formerly known as the Haggs), near Inverkeithny, all in Banffshire, where our highland tourists may see the parties regularly encamped with their portable observatories and instruments all in working order. The general result can be but briefly stated to be a diminution of the deflection as the observers proceed southwards, but how far it may extend is, of course, at present unknown.

NAVAL ENGINEERING.

Channel Fleet Trials.—The following are the returns of trials of this Fleet under sail on 1st, 21st, and 23rd Sept. last:—Sept. 1.—At 2 p.m., up screws and started on starboard tack off Berry Head. Wind westerly; course, south-westerly; sea, smooth; speed, 6 to 7 knots. Position at starting:—*Edgar* to windward of *Black Prince*, 804 yards; *Prince Consort*, 1,290 yards; *Enterprise*, 1,304 yards; *Hector*, 22 yards; *Defence*, 1,404 yards. 3 p.m.—Wind, W.S.W., 6 to 7; course, south; sea, increasing; speed, 7 to 8 knots. *Edgar* to windward of *Black Prince*, 1,790 yards; *Prince Consort*, 2,475 yards; *Enterprise*, 2,050 × 746 yards; *Hector*, 1,050 × 1,028 yards; *Defence*, 1,650 yards. 4 p.m.—Wind, variable. *Edgar* to windward of *Black Prince*, 2,760 yards; *Prince Consort*, 2,700 yards; *Enterprise*, 1,850—200 yards; *Hector*, 2,210 yards; *Defence*, 1,790 yards. 5 p.m.—Wind W. by S., 5 to 6; course, N.W. to N.W. by N.; head sea; speed, 4 to 5 knots. *Edgar* to windward of *Black Prince*, 1,530 yards; *Prince Consort*, 1,420 yards; *Enterprise*, 510—1,340; *Hector* (!), 127—2,093; *Defence*, 340. The *Edgar*, on opening the Start Point, experienced a hard sea; the other ships being far astern, and under the land, were in smooth water, and kept the wind to the westward off the land. Sept. 1—6 p.m.—Wind, W.S.W., 5 to 6; course, southerly; sea, decreasing (under the land); sail, as before; speed, 4 to 5 knots. *Edgar*, to windward of *Black Prince*, 3,690 yards; *Prince Consort*, 3,090 yards; *Enterprise*, 1,410 yards; *Hector*, 2,350 yards; *Defence*, 1,175 yards. Here the ships had got together again, and were sailing on the same terms under the land. The whole result was that the *Enterprise* between 2 p.m. and 6 p.m. had lost on the *Edgar* only 106 yards, but the 4 p.m. diagrams show how it happened. September 21st, off Portland.—All plain sail. Wind, W.N.W.; force, 4; speed, 3 knots; slight head sea. 9.30 a.m.—At starting, *Edgar* to windward of *Hector*, 140 yards; *Prince Consort*, 3,150 yards; *Enterprise*, 1,750 yards; *Black Prince*, 405 yards; *Research*, 2,183 yards; leeward of *Defence*, 865 yards. 10.30 a.m.—*Edgar* to windward of *Hector*, 360 yards; *Prince Consort*, 3,440 yards; *Research*, 3,110 yards; *Enterprise*, 4,110 × 2,350 yards; *Black Prince*, 78 yards; leeward of *Defence*, 1,050 yards. 11.30 a.m.—Wind, variable, westerly. *Edgar* to windward of *Prince Consort*, 3,450 yards; *Research*, 3,580 yards; *Enterprise*, 1,730—2,370 yards; leeward of *Hector*, 2,250—2,610 (!) yards; *Defence*, 1,490 yards; *Black Prince*, 339 yards. 0.30 a.m.—The trial recommenced. Wind, W.S.W.; other conditions as in the morning. *Edgar* to windward of *Black Prince*, 1,100 yards; *Defence*, 9,980 yards; *Hector*, 5,070 yards; *Research*, 4,600 yards; *Enterprise*, 1,750 yards; *Prince Consort*, 6,840 yards. 1.30 p.m.—*Edgar* to windward of *Black Prince*, 2,050 yards; *Hector*, 5,730 yards; *Research*, 5,180 yards; *Enterprise*, 1,880 × 130 yards; *Defence*, 3,520 yards; *Prince Consort*, about 7,680 yards. 2,30 p.m.—*Edgar* to windward of *Black Prince*, 2,190 yards; *Defence*, 3,900 yards; *Enterprise*, 2,580 × 700 yards; *Prince Consort*, about 6 miles; *Hector*, about 7 miles; *Research*, about 5 miles. 3.30 p.m.—*Edgar* tacked to windward of *Black Prince*, 3,030 yards; *Enterprise* (distant 7 or 8 miles), 2,430 — 150 yards; *Defence*, 4,200 yards. 4 p.m.—*Edgar* to windward of *Block Prince*, 3,180 yards; *Defence*, 3,480 yards; *Research*, 6,770 yards; *Enterprise* (distant 2 miles), 1,530 yards. Thus the whole result showed the *Enterprise* gained on the *Edgar* 220 yards, though in each hour when they had been near one another she lost. In the last tack the *Edgar* fell off three-quarters of a point, giving her on the opposite tack a corresponding gain. September 23—All plain sail, with one reef in. 8.40 a.m.—Wind, W. by N., 3 to 4; slight S.W. swell; speed, 4 knots; starboard tack at 9 a.m. At starting, *Edgar* to windward of *Hector*, 23 yards; to leeward of *Defence*, 304 yards; *Prince Consort*, 417 yards; *Enterprise*, 166 yards; *Research*, 225 yards. 9 a.m.—*Edgar* to windward of *Hector*, 439 yards; leeward of *Prince Consort*, 161 yards; *Defence*, 119 yards; *Enterprise*, 271—105 yards; *Research*, 220 yards. 10 a.m.—(At 9·10 a.m. our 1st reefs; speed, 5 knots.)—*Edgar* to windward of *Hector*, 890 yards; *Prince Consort*, 120 yards; to leeward of *Defence*, 260 yards; *Enterprise*, 900—629 yards; and *Research*, 300 yards (both two miles stern). At 11 a.m.—Wind, W. (at 10.30 a.m. tacked). *Edgar* to windward of *Prince Consort*, 3,010 yards; *Hector*, 3,560 yards; *Research*, 918 yards; *Defence*, 1,945 yards; leeward of *Enterprise*, 877 by 73. At noon.—Wind, W.—*Edgar* to windward of *Defence*, 4,740 yards; *Hector*, 6,160 yards; *Prince Consort*, 5,674 yards; *Research*, 2,318 yards; leeward of *Enterprise*, 537 by 340 yards. 1 p.m., Wind, W.—*Edgar*, windward of *Defence*, 7,090; *Prince Consort*, 9,810; *Research*, 3,330; leeward of *Enterprise*, 209—328. Here again, the whole result gives the *Enterprise* an advantage of 43 yards, though whenever we were near we gained on her. Sept. 27.—Off Portland; wind, E.S.E.; force 6; sea, slight; speed, 7½ to 8 knots; single-reefed topsails, topgallant sails and courses. *Enterprise* no topgallant sails.

Edgar gained to windward of	First hour.		Second hour.		Total.
Warrior	1,710	...	1,100	...	2,810
Hector	2,563	...	2,710	...	5,273
Prince Consort	1,460	...	1,620	...	3,080
Defence	2,665	...	1,790	...	4,455
Research	1,880	...	1,100	...	2,980
Enterprise	1,217	...	1,365	...	2,582

The *Enterprise* lost her bowsprit during the second hour, but this only deprived her of a jib.

Trial Trips in the American Navy.—The following code of instructions for the trial of the navy steamers, between buoys two miles apart in New York Bay and Hampton Roads, has recently been issued by the Secretary of the Navy. The maximum speed of naval steamers will be ascertained by trial between buoys two nautical miles asunder, in New York Bay and Hampton Roads. Only the buoys in New York Bay have been laid down. They are two spar buoys painted white, showing about 20ft. out of the water, and bearing from each other W.N.W ½ W., E.S.E.½ E. by compass. The west buoy ranges with Princes Bay Light, and is moored in 27ft. water. The east buoy ranges with East Beacon, on Sandy Hook, and is moored in 26ft. of water. These depths are taken at mean low tide. The position of buoys will be seen on the special of the navy trial course. Each trial is to consist of four runs in each direction, making eight runs in all, and they are to be conducted in the following manner, viz.:—When at the distance of from one-fourth to half a mile from the first buoy, the fires in the furnaces being large, clear, and bright, the steam at the maximum pressure the strength of the boiler will allow, and the water in the boiler as low as safety will permit, the throttle valve is to be gradually opened until the full width is reached and the steamer has its maximum speed as she passes the first buoy. The run thence to the second buoy is to be made with all the speed the vessel can attain. After passing the second buoy, the engine can be throttled down until the steamer is turned, and ready for the return run, which is to be made in the same manner, and so on. During the actual time of running between the buoys, no water is to be "blown off" from the boilers, as little feed water is to be used as possible, and the furnace doors are not to be opened. The blowing, feeding, and firing are to be done while the steamer is being turned. The fires are to be kept level and clean, and free from holes. They are to be composed of egg size anthracite without dust, and are to be carried 7in. thick. The full force of the steam jets in the smoke pipe, or of the fan blast beneath the grate, according as the steamer may be provided, is to be used during the runs, and the edges of the uptake doors are to be luted with fire clay to prevent the admission of air. All the holes in the furnace doors are to be kept open, except when the fan blast is employed. The point of cutting off is to be that at which all the steam generated can be used. With screw engines, before commencing the trials, water will be let on at all the ends of the principal journals, and likewise on the centre of the width of the cranks. A copious lubrication will also be employed. An indicator will be permanently in position on each cylinder, heated up and in good working order. During the whole time of a run, diagrams will be taken as rapidly and as numerously as possible from each end of each cylinder. The discharge water will be carried at the temperature giving the best vacuum. Before commencing the trials all stuffing boxes, and joints to vacuum spaces, will be made tight, and particular care will be taken that the vacuum shall be the maximum possible for the machinery. The trials will be made at slack water if convenient, in order that the tide may effect the result as little as possible. At the conclusion of the trials a report will be made to the Bureau of Steam Engineering, accompanied by all the indicator diagrams taken and embracing the following data, namely:—Time of passing of each buoy on each run; time of making each run; number on counter on passing each buoy on each run; number of revolutions made during each run; mean steam pressure in boiler during each run; mean vacuum in condenser during each run; barometer; temperature on deck, in the engine room, and in the fire room; and of the injection water of the hot well and of the discharge water when the machinery has a surface condenser. The draught of water of the vessel, fore and aft, at the beginning and at the end of the trials; the height from water line to lower port sill or plank-sheer at the middle of the length of the vessel, will be entered in the record. If the steamers have paddle wheels, the lowest immersion of the outer edge of the paddle will be noted at the beginning and end of the trials. Also the diameter over the paddles, their number and dimensions. If the steamer have a screw propeller, the diameter, pitch, and number of blades and length of screw in the direction of its axis, will be entered in record; the force of the wind and its direction relatively to the vessel; the state of the water, whether smooth or rough, &c. The utmost care will be observed in the conduct of the experiment, and the data will be taken with perfect accuracy.

The Screw Steam Gun Vessel "Serpent," 4, 695 tons, 200 horse-power, was taken for trial of her engines at the measured mile off Maplin Sands on the 1st ult. The vessel made six runs at full speed on the measured miles with the following results:—Average speed, 9·724 knots per hour; revolutions of engines, maximum, 77; mean, 76⅔; pressure of steam, 20; vacuum, 24. Two runs were made at half-boiler power, with an average speed of 8.555 knots per hour; the revolutions of engines being, maximum, 68; mean, 67; vacuum, 24½; pressure of steam, 16lb. The vessel was tested on the circle at full and half speed; at full speed, with helm 29½ degrees to starboard, the time of turning the circle was 4 min. 47 secs.; the diameter of the circle being 477 yards. At half-speed with helm to starboard 29 degrees, the time was 5 min. 12 sec.; the diameter of the circle being 449 yards. The vessel is fitted with Griffith's propeller, diameter, 11ft., pitch, 17ft., variable from 14ft. to 20ft., and the draught of water during the trial, which lasted six hours, was, forward and aft, 24ft. The *Serpent* was fully equipped with all her sea stores and armament on board, and was ready for sea. The trial was considered satisfactory.

Russian Iron-clads.—The monitor *Broneuocetz*, on the 28th of September last, underwent a trial of her machinery. The trial proved that this monitor is better than any yet launched. She first made seven knots an hour, and again nine knots. During the entire of her course, the pressure proved 12lb. to 16lb., and the screw made 65 evolutions, The tower moved round without any difficulty. The build of the *Broneuocetz* is superior to that of the monitors *Kaldoun* and *Vechoun*, whose trials were very satisfactory. The tower is better defended, and it is placed in the middle of the ship, while in the *Kaldoun* and *Vechoun* it is placed more forward, which detracts from the strength of the towers, and renders the officer's cabins smaller and less convenient.

Naval Appointments.—The following appointments have taken place since our last: J. Dearden, Engineer, to the *Nimble*; W. Roberts, Engineer, additional, to the *Saturn*. for the *Asp*; J. Stocks, promoted to First-class Assist.-Engineer; R. H. Dohney, First-class Assist.-Engineer, to the *Nimble*; C. Scourer, Second-class Assist.-Engineer, to the *Nimble*; A. M'Leod, Engineer, to the *Sharpshooter*; R. Evans, Engineer, to the *Blenheim*, for the *Hector*; J. Boswell, First-class Assist.-Engineer, to the *Sharpshooter*; C. Salmon, promoted to be First-class Assist.-Engineer, and W. G. F. Colley, Second-class Assist.-Engineer, to the *Sharpshooter*; W. Savage, Second-class Assist.-Engineer, to the *Assurance*; A. Andrews (Acting), S. Judd, L. Blackler, E. Keen (Acting), W. A. Houghton (Acting), promoted to the rank of Engineer; W. Oliver, Chief Engineer to the *Excellent*, for the *Royal Sovereign*; W. Anderson, Chief Engineer, to the *Indus*, for the *Shannon*; B. Hove, Chief Engineer, to the *Indus*, for the *Windsor Castle*; R. Sleeman, Chief Engineer, to the *Asia*, for the *Royal Alfred*; Matthew Kidd, Chief Engineer, to the *Asia*, for the *Vulcan*; J. W. M'Kenzie and J. M'Intyre, Engineers, to the *Excellent*, for the *Royal Sovereign*; W. Giles, Engineer in the *Fisgard*, confirmed; W. H. Barker, First-class Assist.-Engineer, to the *Gladiator*; Henry Onions, First-class Assist.-Engineer, to the *Excellent*, for the *Royal Sovereign*; J. Dinwoodie, First-class Assist.-Engineer, to the *Asia*, for the *Royal Alfred*; W. Lewis, Chief Engineer to the *Indus*, for the *Intrepid*, confirmed; J. Dearden, in the *Asia*, for the *Sharpshooter*, promoted to Chief Engineer; J. Mears, Engineer, for special charge, to the *Asia*, for the *Fairy*; J. R. Ayates, First-class Assist.-Engineer, to *Pembroke*; J. Frazer, W. S. Thompson, and G. Williamson (b), promoted to be First-class Assist.-Engineers; A. Wast, Engineer, to the *Aboukir*, for the *Onyx*; W. Crow, Engineer, to the *Aboukir*, for the *Nettle*; J. Ferguson, Engineer, to the *Hastings*, for the *Gripe*; A. Marshall, Engineer, to the *Indus*, for the *Espoir*; W. Owen, Engineer, to the *Indus*; S. Lloyd, Second-class Assist.-Engineer, to the *Hawke*; F. A. Bulley, Chief Engineer, to the *Cumberland* for the *Basilisk*; A. Pritchard, in the *Euryalus*, and F. C. Kelson in the *Antelope*, promoted to Acting Engineers; S. Grundy, in the *Fawn*, promoted to First-class Assist.-Engineer.

MILITARY ENGINEERING.

MAJOR-GENERAL HUTCHINSON'S GUN.—A gun has been invented and patented by Major-General Hutchinson, commanding in the West of England; and if the expectations of the inventor be only partially realised, great changes will take place in the construction of much of our ordnance. The objects sought to be accomplished in the new gun are—First, that it shall weigh little more than twenty times instead of 800 times the weight of the shot, as is usual; secondly, that without friction, it shall impart rapid rotation to the shot; thirdly, that the shot shall be of the form best adapted for penetrating the air and target; and, lastly, that it shall leave no vacuum behind it, and not reochet when it strikes water. A few experiments have already been made at Plymouth on board the gunnery ship *Cambridge*. The gun is somewhat like a lengthened mortar. The chamber is of the usual cylindrical form, but only sufficiently long to hold the powder and wadding. It is at the mouth that the chief peculiarity occurs. The shot is termed disc shot, and those used on this occasion were about the size of two very small plates placed against each other, excepting that the edge is sharp. The muzzle of the gun is much enlarged, and is formed so as to receive with greater exactness the inner half of the disc shot. The more accurate the fitting is, the less the escape of gas, and the truer the aim that can be taken; when in place, the outer edge of the shot is flush with the muzzle of the gun. The shot weighed 4lb. 2 oz., the charge of powder, 6 oz., being one eleventh part the weight of the shot. The gun was of nearly 200lb weight, double, the inventor said, what it ought to have been. The first trial was at the 1,000 yard's target, the shot going in a good direction, and pitching 100 yards beyond the mark. The two other experiments were at 13 deg. elevation for range, and 4 deg. for aim; but in neither case, owing to the tide being out, could the position of the shot when it fell be observed. The experiments, so far as they went, were considered satisfactory. When in the gun the shot stands in a vertical position, and rotation is caused by the axis of the chamber lying above the centre of the shot, and by a small projection in the interior of the muzzle at the bottom, meeting the edge of the shot. From the shortness of the gun it possesses some of the advantages of a breech-loader, and from the simplicity of its construction, and the little metal used it may prove both a cheap and easily handled gun. The carriage is fitted with a number of galvanised india-rubber cylindrical buffers (in contact by their sides not extremities) placed in grooves on the flanks of the guns; these received the recoil. By a similar arrangement the rebound is received in a series of rings fixed below the gun.

STEAM SHIPPING.

STEAM SHIPBUILDING ON THE CLYDE.—The *Lord Clyde*, a double screw steamer, on her trial trip ran the measured mile at the rate of 15 knots per hour. The *Lord Clyde* was recently launched by Messrs. Blackwood and Gordon, and is intended for the East Indian trade. The *Kenilworth*, a paddle steamer, in "running the lights," attained a speed of 14 to 18 knots per hour. This vessel, which is intended for the Nassau trade, was built by Messrs. Scott and Co., and is 400 tons burden and 120-horse-power. The *Moravian*, screw mail steamer, has also "run the lights," although her engines were not put at full speed during the trip.

PADDLE-WHEELS.—Our contemporary (the *Scientific American*) in a recent number with regard to paddle-wheels, states:—Much ingenuity has been expended in the endeavour to cause the paddles of the wheel to enter and leave the water vertically. Had this been found beneficial, the complexity and liability to derangement might have been submitted to; but the reverse is the result of various trials. If the vertical paddle had been considered and acted on as the essential and natural form for propulsion, the inventor of the simple radial arm paddle would have merited undying fame. By the combined motion of the vessel forward, and the paddle downward, the entrance to the water is nearly edgewise at any material angle; whereas, the entrance and exit of the vertical paddle "backs water" by the forward motion of the vessel. The superiority of the radial paddle is still further seen, admitting an oblique action (not edgewise) by the fact that such oblique action would not *per se* be injurious, or only slightly or incidentally so, by increased slip, which item (slip) is waived for the present. Then the wheel arm being vertical, with a given movement of the crank and expenditure of steam, the vessel is moved a certain distance; with the wheel arm horizontal, if immersed to the axis, there would be no movement of the crank or vessel, and no steam used. Now between the vertical and horizontal positions the required force or quantity of steam, to move the crank in equal distance, would be determined by the angle of obliquity, and the progress of the vessel would be increased as the quantity of steam used, under the said equal movement of the crank, being in action and effect similar to increased pitch of the screw propeller. The assumed loss by oblique action is one of several oversights in orthodox mechanics, and is estimated to be generally about 15 per cent., which would give an angle of 9 degrees as the mean point of impact on the water. The usual mode of ascertaining the slip is free from error, and may average 12 per cent., which would be increased with the angle in the ratio of the square root of the required form. While it is contended and made prominent by orthodox authority, that the loss to the paddle is, say 14 per cent., the details of the properties of the screw propellers are given without any reference to obliquity, which cannot be generally less than 30 degrees, entailing a loss, by the same rule, of 50 per cent. Consistency requires that this large deducive loss be acknowledged, although experience shows an advantage of to 15 per cent. over the paddle wheel in economy of steam. The cause of the superior efficiency of the screw propeller may be found in the partially dead water against which it acts, yet avoiding the drawing back of the vessel, owing to the continued advance, beyond the immediate influence of the backward ejected water.

LAUNCHES.

LAUNCH OF THE "LORD CLYDE" AT PEMBROKE DOCK.—The *Lord Clyde* iron-clad steamship was launched at Pembroke Dock on the 10th ult. The following are the dimensions of the *Lord Clyde*:—Length between perpendiculars, 280ft.; length of keel for tonnage, 233ft. 11¾in.; extreme breadth to outside of armour, 58ft. 9in.; ditto tonnage, 57ft.; moulded, 56ft.; depth of hold, 30ft. 9in.; burden in tons, 4,067. The *Lord Clyde* will carry 36 guns.

THE "ABIGAIL" paddle-steamer, was launched on the 15th ult., from the yard of Mr. W. C. Miller, of Liverpool. The vessel is in length 262ft. over all, 30ft. breadth of beam, and 14ft. depth of hold, with a tonnage of 1,110 full measurement She will be fitted with engines of 300 horse-power, manufactured by Messrs. James Watts and Co.

THE "GUNGA" iron-built steamer, was launched from the yard of Messrs. C. and W. Earle, on the Humber, on the 18th ult. Her length is 280ft; breadth, 20ft.; and tonnage, 1,257 tons. The *Gunga* has been built for the Calcutta and Bengal Steam Navigation Company, and is intended for the Bombay and Calcutta trade.

THE LAUNCH OF THE "ROSINE" steel built paddle-steamer, from the building yard of Messrs. Jones, Quiggin, & Co., Liverpool, took place on the 15th ult. The dimensions of the *Rosine* are as follows: Length, 260ft. keel and forerake, and 270ft. over all; breadth of beam, 33ft.; and depth of hold, 15ft. Her tonnage, builder's measurement, is 1,391 tons; and she will be fitted with engines of 300 horse-power, constructed by Messrs. James Watt and Co., of London and Birmingham. She will also be fitted with steel rigging.

THE LAUNCH OF THE ROYAL ALFRED took place at Portsmouth, on the 15th ult. The *Royal Alfred* is one of the *Prince Consort* and *Royal Oak* class, their frames designed and prepared as 92-gun screw line-of-battle ships, but afterwards cut down to a frigate's battery, altered in form at the bow and stern, and strengthened considerably in every part to carry the weight of 4½in. armour plating. The *Royal Alfred* was ordered to be built as a line-of-battle ship in October, 1859, of the following general dimensions:—Length between perpendiculars, 252ft.; length of keel for tonnage, 213ft. 9½in.; breadth extreme, 58ft.; breadth for tonnage, 57ft. 2in.; breadth moulded, 56ft. 4in.; depth in hold, 19ft. 10in.; burden in tons, 3,715 62-94. The ship was accordingly laid down and nearly completed in accordance with these orders, when, after the work had been suspended on her for some time, just at the period when wooded liners had become universally acknowledged as useless to compete with ironclad frigates, a second order relative to the ship was issued from the Admiralty in June, 1861, which on this occasion directed that the ship's upper deck, so far as it had been constructed, should be removed, and the necessary alterations and strengthening of her frame carried out, to complete her as an iron-cased frigate. Under these new conditions the *Royal Alfred* has been sufficiently completed to be launched from off the shipway on which she has been constructed, her hull shorn externally of all aids to her beauty, her bows without the "figure-head," or the curved lines of head-rail and cutwater, and her stern without the ornamental quarter-galleries, and reduced to a bare conical termination, the apex projecting over and protecting the fixed screw and rudder; her length is now increased beyond her original dimensions to 273ft. between perpendiculars and 233ft. on her keel, and her tonnage increased to 4,045 26-94, while her breadth remains the same. Like others of her class, the *Royal Alfred* does not look much handsomer afloat than she did on the stocks, but in the absence of beauty there is evident fitness for fighting purposes as a broadside ship, looking at her superficially as she lay broadside on to the building shed, and brought up in that position by her anchor immediately after being launched. The upper deck of the *Royal Alfred* is composed of the ordinary wooden planking; but this is laid upon an iron deck of half-inch boiler plate, which, strengthened and tied by edge and butt straps of iron of equal thickness, and by fore and aft stringer rows of plates, rests upon rolled iron beams which span the ship at short intervals. The deck, from beam to floor, is of good height, there is ample room for working the guns of the battery fore and aft, the means of ventilation for carrying off the smoke in rapid firing are good, and, to crown all, the entire deck, round the stem and stern, as well as on the broadside, is protected by 4½-in. rolled armour-plates, from the Atlas Works, Sheffield. Descending lower into the ship, workmen are found busily employed fitting the mess, berthing, &c., for the crew; and still lower may be seen the preparations made for the reception of her machinery. Neither machinery nor armour-plates yet form part of the *Royal Alfred*, and both will have now to be fitted in dock or in the floating basins of Portsmouth yard, as may be required, according to the progress of the ship's outfit. The engines will be of the united power of 800 horses, nominal, from the establishment of Messrs. Maudslay, Field, and Co. The lower masts of the ship are splendid specimens of iron manufacture, from the works of Messrs. Finch, of Chepstow. The *Royal Alfred* is pierced for 35 guns, but with the rapid strides now being made in the calibres of naval ordnance it would be useless to speculate upon what her armament may eventually be.

TELEGRAPHIC ENGINEERING.

THE TELEGRAPH BETWEEN LONDON AND AMERICA.—From advices received in Liverpool from New York we learn that the Western Union Telegraph Company, who, in connection with the Russian Government, have this great enterprise in hand, are actively engaged in fitting out an expedition under the immediate supervision of Capt. C. S. Bulkeley, of the United States army, for Oregon, the coast of Russian America, and the country lying beyond Behring Straits, to survey the route of the telegraph line, and make all other needful arrangements for putting the whole extent of the line under contract the ensuing year; and it is said that the projectors of the enterprise are sanguine that the line will be in successful operation between New York, San Francisco, St. Petersburg, and London about the middle of 1866.

TELEGRAPHIC PROGRESS IN SOUTH AUSTRALIA.—The number of telegraph stations which were open in South Australia during 1863 was thirty-six, and the miles of line in operation were 747, with 1,064 miles of wire. The net revenue obtained was £8,429, and the outlay for working expenses and maintenance of lines was £9,107, showing a loss of £678, which is accounted for by the number of unremunerative country stations in different parts of the colony. The business transacted with the other colonies last year produced the following amounts:—With Victoria, £5,085; with New South Wales, £2,853; and with Queensland, £188. In South Australia the total receipts were £8,695, against £8,047 for 1862, and £7,382 for 1861. The stations which pay are, Adelaide, Port Adelaide, Gawler, Kapunda, Clare, Burra, Kadina, Wallaroo, Port Elliot, Robe, Mount Gambier, Penola, and MacDonnell Bay. The stations of Yankalilla, Wellington, and Kincraig just pay their expenses. The extensions during the year were from Kadina to Port Wallaroo, and from Penola to Kincraig.

RAILWAYS.

THE ATLANTIC AND GREAT WESTERN RAILROAD.—The first through train from New York to St. Louis, by the broad gauge, over the Atlantic and Great Western Railroad, reached its destination in 44 hours, a distance of 1,200 miles, without change of carriages or break of gauge.

THE RAILWAY CLEARING-HOUSE, being essential to the railways, has naturally kept pace with their multiplication. In 1845, three years after its first establishment, the number of companies on its books was only 16: ten years later it had arisen to 73; and it is now 110, with a united mileage of 10,859 miles. The number of companies does not give an adequate notion of the growth of business, in consequence of the leasings and amalgamations which are always going on. The Clearing-house knows only the companies which actually work the lines, and deals only with the interchanged traffic, without touching that which is confined to the line of any particular company. The number of stations sending traffic returns monthly is as follows:—Goods and cattle stations, 3,121; passenger stations, 1,817; parcel stations, 2,368. The number of pairs of stations between which bookings are carried on monthly is:—Goods and cattle, 62,470; passenger, 15,145; parcels, 16,626. The average number of railways over which each consignment of goods is conveyed is 3·08; each passenger, 3·46; each parcel, 3·07. The gross receipts for twelve months amount to an aggregate of £8,044,791, as compared with £401,651 in 1845, and £4,829,649 in 1855. The present total is thus composed:—Goods and cattle, £5,937,753; passengers, £1,805,915; parcels, £301,123. Total amount of receipts of traffic of all kinds cleared since the establishment of the office, £81,000,000.

RAILWAY PROGRESS IN SPAIN.—Recent statistics show that the mean length of railway worked in Spain in 1861, was 2,119 kilometres; in 1862, 2,327 kilometres; and in 1863, 3,154 kilometres. The rough receipts acquired were, in 1861, £1,739,344; in 1862, £2,045,267; and in 1863, £2,549,144. A kilometre, is five-eighths of an English mile.

GREAT EASTERN AND LANCASHIRE AND YORKSHIRE RAILWAYS.—We (*Herepath*) understand that the arrangement between these companies is that the application to parliament for the coal line lost last session is to be renewed, and to be prosecuted vigorously next session, and that the expense of the application and cost of construction, if an act be obtained, is to be borne equally by the two companies, the object being a future amalgamation of the two great lines.

WEST NORFOLK JUNCTION RAILWAY.—The ceremony of cutting and turning the first sod of this projected line of railway, which is to connect the Lynn and Hunstanton Railway at Heacham with the Norwich and Wells Railway, at the Wells station, took place

on the 8th ult. This undertaking will give railway accommodation to the north-west district of the county, which is chiefly first-class arable land, and supports a large agricultural population. It is proposed to erect stations at Ringstead, Docking, Burnham, and Holkham. The whole distance of the line is 18 miles, and the estimated cost is £97,000.

Reduction of Railway Rates.—The council of the Leeds Chamber of Commerce have for some time past urged upon the several railway companies carrying between Leeds and London, the propriety of making their rates more in accordance with those from Manchester and other Lancashire towns. These efforts have been attended with success, and the president of the chamber has received letters from the various railway companies, stating that in future the rates to London for linen, cotton, woollen, and worsted goods, including yarns conveyed direct for export, are reduced from 43s. 4d. to 35s. per ton: while those for horse rugs, soldiers' clothing, railway rugs, serge, woollen cloths, balk cloth, stuff goods, and cotton crapes, are reduced from 50s. to 42s. 6d.

Anthracite as a Locomotive Fuel.—The result of long practical trials on the Pennsylvania and Reading Railroad is that anthracite, when properly used, surpasses every fuel that has been applied to locomotive purposes. It is considered that the idea "that anthracite will not do" is just as fallacious as it is unjust to the experience of scientific men who, in their construction of engines on which it is alone used, have fully proved its excellence. By slightly modified arrangements almost any engine can be converted into a coal burner. The trials of the Schuylkill anthracite affords conclusive evidence of its utility, and that, with an average of six cars attached, the coal consumed per mile was under 23lb.; that the number of miles ran per trip was 95; that the trips were all run with "exhaust" and "throttle" wide open, the speed of the engine being regulated by the reverse lever. Twenty-two stoppages were made between Philadelphia and Pottsville, the speed being nearly 26 miles per hour; the maximum grade on road, 24ft. per mile; the average inclination of road, 6·16ft. per mile. The average weight of the train was upwards of 80 tons. We understand that on his recent visit to Portugal Mr. Nicholas Ennor procured some samples of an anthracite coal which he anticipates may be successfully employed for the purposes of steam generation. It is at present used in the locality of the workings, mixed with English coal in about equal quantities, and is considered to be well suited for smelting iron.

French Railways.—A publication recently issued by the office for railway statistics established at the Ministry of Commerce, Agriculture, and Public Works, contains some interesting details. The total length of railway open to the public during the year 1862, was 57,209 kilometres (five-eighths of a mile each), which produced 2,000,735,007f., or an average of 34,962f. per kilometre. The receipts per kilometre in the different countries of Europe were as follows:—France, 45,781f.; Great Britain and Ireland, 40,417f.; Saxony, 37,152f.; Austria, 33,709f.; Prussia, 30,945f.; Belgium, 29,712f.; Wurtemburg, 27,068f.; German Duchies, 26,423f.; Russia, 26,045f.; Holland, 26,008f.; Hanover, 24,007f.; Italy, 22,070f.; Bavaria, 21,737f.; Spain, 20,966f.; Denmark, 15,207f.; Portugal, 9,801f.; Turkey, 5,028f.; and Sweden and Norway, 4,383f. The cost of construction of the French lines, consisting of a network of about 20,000 kilometres, is estimated at an average of 362,950f. per kilometre, at the charge of the companies. If that outlay is compared with the gross receipts of 45,781f. per kilometre, which is reduced by the working expenses (about 40 per cent.) to 27,469f., the result will be that the capital invested in the form of shares or obligations, produces a revenue exceeding $7\frac{1}{2}$ per cent. Such a return, without being excessive, would be satisfactory if the companies could consider it to be definitively acquired, but such an illusion is not to be permitted. There still remain 10,000 kilometres to be opened, and admitting that they will produce an average of 30,000f. per kilometre, this second portion of the French network will only leave a clear income of 15,000f., deduction being made of 50 per cent. for the working expenses, the proportion of which increases as the gross receipts diminish. So that the net produce per kilometre being destined at a future date to amount to 21,234f. 50c. only for the whole of the French network, that average will represent but 5f. 85c. per cent. of the capital invested, a rate corresponding exactly with that at which the companies contract their loans. As to the engagements to assure the execution of the French lines, entered into by the public Treasury, which has to aid the companies in paying the interest on the capital absorbed, when they are unable to do so themselves, the guarantees granted to the railway companies may be estimated as likely to amount in eight or ten years to 30,000,000f. annually. That is no doubt a considerable sacrifice, but one justified by the grandeur of the work which will then be accomplished.

Railways in Natal.—A colonial paper says the nominal capital of the Natal Central Railway Company is subscribed. It proposes to construct a line of railway suited to general traffic from Durban to Maritzburg; this line is to be carried round by the Ispingo and between the Umlaas and Illovo Rivers to the capital of the colony, a distance of about 70 miles. But the precise line of route must not be viewed as finally fixed, and should any shorter and more direct route than that at present surveyed be pointed out, the Company will gladly adopt it. In the Bill submitted by the Company, distinct provision is made for an alternative line for the last 15 miles of the distance to be traversed, that is, for the portion nearest Maritzburg. A line 50 or 60 miles long would be worked at much less annual cost than a line 20 miles longer, and which passes through country that would for some time to come present few inducements in the shape of intermediate traffic warranting a deviation. Upon this line a government guarantee is asked by the Company of 6 per cent. on the capital expended. That capital is nominally fixed at £600,000, but presuming the line should be 70 miles in length, it might be £50,000 more. This guarantee, then, may be looked upon as essential in one shape or other to the construction of railways in Natal. And in return for this concession, the government must also exact several necessary conditions. Power of supervision is maintained over the working and regulation of the line; thus a check is placed upon extravagance, needless expenditure is curtailed, and the Company is compelled to work the line at the minimum cost. But this is not all. One very important feature of the system, and one that has been almost wholly overlooked, is that the sums paid by a colony towards the guarantee are not lost for ever. They come back to the exchequer. Whenever the line pays more than the guaranteed per centage, the Government steps in and shares these profits. This may be confirmed by citing the case of India; there, up to the 31st of December, 1861, the Government had paid altogether on account of guarantee £6,286,895; but it also had received back and had to place against that £1,250,000 sterling. This, too, was at a time when few of the lines constructed were completed—when few of them were yet in a position to make returns. There are, of course, other concessions given in addition to a money guarantee, such as grants of land or mining rights. These are what the coal company ask, and it seems probable that an Overberg Railway would be cheaply obtained at a sacrifice, say of 600,000 acres of waste land, and of a mining monopoly for twenty years over a certain area of country.

RAILWAY ACCIDENTS.

Destruction of Railway Waggons.—On the 5th ult., at noon, an accident occurred to a train of loaded coal waggons, about five miles east of Darlington. A train, consisting of upwards of 80 chaldron waggons, was on its way to the Middlesborough district, and when near Fighting Cocks the wheel of the first waggon broke, causing the other waggons to leap upon one another and rush down an embankment of considerable height. The adjoining fields for a great distance around were strewn with coal, coke, broken wheels, and the shattered waggons, upwards of seventy of which were rendered useless. Both lines were blocked up for more than two hours. The telegraph was also broken.

Accident on the Great Northern.—An accident unattended with loss of life, occurred at the Welwyn station on the Great Northern Railway on the night of the 7th ult., this station being about 20 miles from King's-cross, on the main line. It appears that the down north express left King's-cross about seven o' lock. It was a somewhat light one, consisting only of seven or eight carriages, and proceeded without stoppage to the scene of the casualty, at the rate of between thirty and forty miles per hour. At Welwyn, in common with the majority of all the stations on the Great Northern line, there are sidings for the reception of goods trains and others necessarily shunted to facilitate the passage of the expresses, and it appears that at the time when the train from London was due a number of carriages from Peterborough and Hitchin for the metropolis, laden chiefly with grain, flour, and vegetables, were being driven across the down line to the sidings. Almost before the driver of the express was aware of the obstacle in his front his engine had dashed through the goods vans, scattering their fragments and their contents in every direction, and covering both the up and down lines, and the right and left of the railway, with the debris. The engine of the passenger train was thrown off the rails, but both the fireman and stoker escaped with comparatively slight injury. Two or three of the carriages next the engine were smashed, but fortunately, through the train being unusually light, they were wholly unoccupied. In the other portions of the train many contusions were occasioned.

DOCKS, HARBOURS, BRIDGES, &c.

The Railway Bridge at Blackfriars.—Messrs. Kennard Brothers, of Crumlin Ironworks, near Newport, Monmouthshire, were the contractors of this bridge, and Mr. Friend French the practical engineer. It is 939ft. long, 56ft. wide, and the lattice girders at the sides and along the centre are 15ft. high. The total weight of the iron in this portion of the bridge alone is 3,000 tons, and the exact number of rivets fixed in it is 603,682. A new feature on this bridge, when altogether finished, will be that along the tops of the cross elliptical braces on both sides of the railway 20 lines of telegraphic wire on each side will be fixed, making 40 in the width of 56ft., thus making a kind of curve overhead, which will have a very pretty and unique appearance.

The Bridge over the Niemen at Kovno.—This is a plate-girder bridge, remarkable for the length of the spans, and the peculiar formation of the piers. It is, in fact, very much like the Victoria-bridge at Montreal, with the exception of the spans of the girders and the piers that support the intermediate portions of them. The bridge is built rather on the skew, so that the axis of the piers is made parallel with the axis of the current; and as the Niemen carries down great hammocks of ice in the spring, it is found necessary to protect the piers by ice-breakers that are supported on iron cylinders of the same diameter as those that form the piers. There is little art in the design of this bridge; it is composed simply of two longitudinal girders, resting upon vertical supports, which are as bald and tame as possible; yet the simplicity of the means employed contributes to give an air of sublimity to the composition of the bridge. The girders are, however, different from those of the Victoria-bridge, to which they have been compared, inasmuch as they do not form parts of a tube with rectangular cells at the top and bottom; they are simple girders, which support the roadway at the lower level, and are kept in place at the top by a system of cross braces. The piers were formed of cast iron, and they are sunk in the manner that is now so common on the continent, viz., by the means of compressed air, and their interior is then filled in with concrete; they bear on their upper surface the rolling carriages of the girders and the iron casing of the ice-breakers. Much ingenuity has been displayed in the contrivances for carrying the roadways. It may be as well to add that the ice-breaker is composed of wrought iron plates, and that the struts between the piers are of cast iron.

Dock Accommodation at Cardiff.—It is reported upon good authority that the trustees intend to again apply to Parliament for powers to make additional dock accommodation at Cardiff, notwithstanding the loss of the gigantic scheme at the last session of Parliament—probably the largest scheme introduced at the time. It is believed that while they will again apply for the construction of a landing pier at low water mark, the plans of the new dock will include only such land as belongs to the Marquis, so that the question of interfering with the anchorage ground of the Bristol Channel will not be raised.

Failure of a Railway Bridge.—Recently one of the new iron bridges which carries the Whitby deviation railway across the Ellerbeck, in Gothland, broke under the weight of a passing engine. The engine fell through, but the men escaped.

Holborn Valley Viaduct.—Notices to quit are now being served by the corporation on the owners and occupiers of the properties required for this improvement on the south side of Skinner-street, Snow-hill, and Holborn-hill. Several houses also required for the purpose at one end of Shoe-lane, adjacent to the church of St. Andrew, Holborn, are about to be disposed of with a view to the demolition and the commencement of the works.

MINES, METALLURGY, &c.

Melting and Casting Steel and other Metals.—A new system has been patented provisionally by Mr. Rochussen, who claims for it the advantage of great saving in labour, fuel, fire-clay, crucibles, furnace-bars, &c., and in shortening the time required for melting, and running; less danger of injury to the metal by the action of oxygen, carbonic oxide, carbon, and sulphur. The temperature of the furnace is said to be completely under control. The patentee claims, as entirely new and peculiar, the principle of—1st, casting without removing the crucible from the furnace; 2nd, that of filling the whole capacity of the crucible with molten metal, by means of charging the hollow cover.

Ancient Mining Machinery.—An ancient mining wheel, upwards of 20ft. diameter and 1ft. 6in. breast, of considerable interest to mining antiquaries, has recently been exhibited at the Academy of Arts et Metiers, at Paris, by Mr. A. Sanson, who reports that it was discovered in a Portuguese mine, and was doubtless employed by the Romans to raise water in the operation of draining the mine. It is well known that the hydraulic works of the Romans surpassed in extent any of those of modern times. As that great people had not the use of either steel or gunpowder, they were sometimes obliged to raise water over a ledge where modern engineers would carry it right through. In some of the mines of San Domingos they make adit levels nearly three miles in length, but in some places the water was raised by wheels to carry it over rocks that crossed the drift. Eight of these wheels have recently been discovered by the miners who are now working the same old mines. These wheels are made of wood—the arms and felloes of pine, and the axle and its support of oak—the fabric being remarkable for the lightness of its construction. It is supposed that these wheels cannot be less than 1,450 years old, and the wood is in a perfect state of preservation, owing to its immersion in water charged with the salts of copper and iron. From their position and construction these wheels are presumed to have been worked as treadmills, by men standing with naked feet upon one side. The water was raised by one wheel into a basin, from which it was elevated another stage by the second wheel, and so on for eight stages.

Manufacture of Tubes, Rods, and Plates.—According to the invention of Mr. G. P. Harding, an expanding die or draw-plate is used, by means of which conical or cylindrical tubes, or tubes of octagonal, square, or other section, outside of different sizes, may be drawn. The machinery employed is composed of a cast iron box, in which is inserted four loose pieces of metal, with slots to receive four draw-plates. The tube is drawn over a mandril, and through the draw-plates fixed (say) at 1in. diameter; but as the drawing proceeds the draw-plates expand by the action of the driving pinion on the bevelled wheels and screws, and if the original reduction of the tube by the draw-plates

be ¼in., it can he lessened gradually to nothing in 6in., 12in., or more of length, so that by repeating the draw and reduction, conical tubes with a cylindrical bore would be obtained perfectly true throughout. In order to obtain a tube conical both internally and externally, he employs a mandril tapered to the cone required, and a tube slit in four places at one end, with an inner tube also slit, projecting a short length beyond the outer one.

HOW COAL MAY HAVE BEEN FORMED.—Sir C. Lyell statement that the ancient seams of coal were produced for the most part by terrestrial plants of all sizes, not drifted, but growing on the spot, is a theory more and more generally adopted in modern times; and the growth of what is called sponge in such a swamp and in such a climate as the Great Dismal (of America) already covering so many square miles of a low, level region, bordering the sea, and capable of spreading itself indefinitely over the adjacent country, helps us greatly to conceive the manner in which the coal of the ancient carboniferous rocks may have been formed. The heat, perhaps, may not have been excessive when the coal measures originated, but the entire absence of frost, with a warm and damp atmosphere, may have enabled tropical forms to flourish in latitudes far distant from the line. Huge swamps in a rainy climate, standing above the level of the surrounding firm land, and supporting a dense forest, may have spread far and wide, invading the plains, like some European peat-mosses when they burst, and the frequent submergence of these masses of vegetable matter beneath seas or estuaries, as often as the land sank down during subterranean movements, may have given rise to the deposition of strata of mud, sand, or limestone, immediately upon the vegetable matter. The conversion of successive surfaces into dry land, where other swamps supporting trees may have formed, might give origin to a continued series of coal measures of great thickness. In some kinds of coal the vegetable texture is apparent throughout under the microscope; in others it has only partially disappeared; but even in this coal the flattened trunks of trees of the genera *Lepidodendron Sigillaia*, and others, converted into pure coal, are occasionally met with, and erect fossil trees are observed in the overlying strata, terminating downward in seams of coal.

MANUFACTURE OF ARTICLES FROM CAST-IRON.—Mr. Neil M'Haffie, of Glasgow, claims the making of castings of white hematite, or the mixture of this with mottled or grey, and very gradually cooling the said casting in an oven or furnace, the moulds being placed therein and heated before the metal is placed in, or the castings being produced, out of the furnace, and afterwards placed therein. The invention is applicable more especially to the manufacture from cast-iron of articles which are required to combine great toughness with considerable or great hardness, as, for examples, projectiles (suitable for the penetration of armour-plates), plates, and slabs for batteries, dies of large size for stamping metal, and many other articles. He takes cast-iron of a very hard nature, by preference white hematite pig, or a mixture of this with mottled or grey hematite pig, which if cast in the ordinary manner would be too hard to be conveniently cut and worked. For many classes of castings it is found that all white pig may be used, whilst in other cases more or less of the mottled or grey pig may he mixed therewith, and still produce castings of the requisite hardness. He has found a mixture of two parts of white and one part of mottled hematite pig to be a good working mixture. This metal he casts in a mould of fire-clay or other material, which is kept heated in a furnace to a red heat, or hotter. A mould of sand, mixed with a little lime, he finds suitable for many purposes. The metal is run into the mould, and is gradually cooled down in the furnace, the cooling being made to occupy from 30 to 72 hours, or longer, for very large sizes. The gradual cooling of the metal ensures uniformity of structure throughout the mass. Afterwards, although the metal is still hard, it can be turned and shaped, if necessary. If greater hardness be required, the article (after turning and shaping, if these processes are resorted to) may be hardened by reheating and plunging, as is practised when hardening steel. The hardness, also, may, if required, be afterwards adjusted by a process of tempering, as is practised with steel. The furnaces or ovens may be made of any convenient forms, and the heat, by preference, used for the harder mixtures—that is, with most white pig in the mixture—is from a full red to nearly a white heat, or even higher, and for the softer mixtures from a full red heat down to a red heat. Castings from similar mixtures may be made in the usual way, either in dry sand, green sand, or loam moulds, but instead of letting them cool in the usual way they are taken out of the mould as soon after solidifying as possible, and placed in the furnaces or ovens, heated as before mentioned, and then left gradually to cool, as in the former case. This process does not usually produce such good results as pouring the metal whilst the moulds are in the furnace or oven, but is sometimes more convenient.

GAS SUPPLY

NEW GAS-LIGHTING APPARATUS.—Mr. T. C. Ebdy and Mr. M. Burdon, of Durham have brought out an apparatus for lighting gas, intended to obviate the necessity of its being done by hand. It is called the "Electro-magnetic gas-lighting apparatus." The invention may be applied to any description of gas-lamp without their requiring alteration. The apparatus is about three times the size of a lady's thimble, and very much like an ordinary gas-burner. The principles upon which it is based are stated as follows:—An ordinary telegraph wire communicating with the negative pole of a galvanic battery is connected with the "Electro-Magnetic Burners" in succession, according to the number of lights required, and the extremity of the wire communicates with the earth, or is conducted back to the battery, and attached to the positive pole, when the circuit is complete. Therefore, to light and extinguish the lights it is only requisite to connect or disconnect one of the poles of the battery. Immediately the electric current enters the "Electro-Magnetic Burner" it passes through an insulated wire, which is wrapped round a soft iron tube, which immediately becomes a powerful magnet, and attracts a piece of soft iron, which opens a kind of valve, and permits the gas to escape through the burner: at the same time the gas-valve is opened, the current passes through a piece of platinum wire close to the burner, which turns red-hot and lights the gas. This effect is produced at every burner at the same instant.

BOWNITCH'S NEW HYDROCARBON LIGHT.—This new method of carburetting coal gas, the invention of the Rev. W. R. Bowditch, has been recently shown in London. The method differs from all others hitherto in use, the inventor employing naphthaline and the heaviest hydrocarbons as the carburetting agents. These are placed in a gas-tight metallic box into which are soldered two gas-pipes—one for conveying gas into the box, and the other for conveying gas and vapour out of the box to the burner. The burner is fixed to the outlet pipe, and so placed that when gas is being burnt the hot air from the gas flame must impinge upon the box. This box is provided with a screw-plug through which the hydrocarbon is put into it, and this plug is closed during use. The box being supplied with hydrocarbon is connected with any ordinary gas-fitting, and the gas is lighted. At first, the gas passes over the surface of the hydrocarbon without being affected; but when the temperature has risen sufficiently to convert the hydrocarbon into vapour, the passing gas carries with it a quantity of the vapour, and the flame becomes highly illuminating, the illumination being proportional to the quantity of vapour present in the flame.

EXPLOSION OF GAS IN THE BIRMINGHAM HOSPITAL.—On the 6th ult., an explosion of gas took place in one of the detached wards of the General Hospital, Birmingham, by which much damage was done to the building, although no personal injuries of a serious character were sustained. It appears that a gas-fitter was searching for a leak in the pipes with a lighted candle, and had lifted up some boards of the floor when an explosion took place. Other explosions immediately followed in the empty rooms adjoining, which knocked out the walls. The side of the house was blown out from bottom to top. Six rooms were laid open to the air by the explosion, the outer wall of one of them being blown out; the separation took place on a level with the bottom of the window, and the opening made might have been cut with a chisel, it was so straight.

GAS EXPLOSION AT BRADFORD.—On the morning of the 5th ult., a fire broke out at Thornton, near Bradford. About 11 o'clock flames and smoke were seen to issue from Dole Mill, in that village, which belongs to Messrs. Joseph and Frank Craven, manufacturers. The fire took place in the warehouse, a large building five stories high, which fronts towards the end of the mill, the communication between the two being by means of a gangway to each other, about seven yards in length. The several rooms of the warehouse were filled with valuable manufactured goods, and also with large quantities of silk and cotton warps and other valuable commodities. In the top room was stowed an immense quantity of old geer, made of cotton, steeped in oil, rendering them extremely inflammable. It appears that the tap, which supplies not less than 30 lights in the stove, had been turned, and after the gas had been escaping for some time a match was lighted, and an explosion of gas immediately ensued, igniting the combustibles previously referred to, and in a most incredible short space of time the building was on fire.

WATER SUPPLY.

WATER SUPPLY FOR GAINSBOROUGH.—A water-works company is about to be formed at Gainsborough.

WATER SUPPLY AT HORSFORTH.—The late scarcity of water having been seriously felt at Horsforth, a number of the inhabitants of that place resolved to form a joint-stock company for the purpose of establishing water-works.

COAL AND WATER SUPPLY AT NELSON, AUSTRALIA.—Two bills have been prepared by the Nelson Government for this purpose. The object of the coal bill is to authorise the Superintendent to raise a loan of £50,000 for the purpose of opening and working the mines in the province. This loan it is proposed to raise by debenture of £100, bearing 8 per cent. interest, payable half-yearly out of the revenue of the province. A sinking fund of £2 per cent. per annum is provided for the liquidation of the debt, such sinking fund to be invested in such manner as the government shall direct. The total debt of the Province of Nelson, after deducting the share falling to be borne by the now distinct Province of Marlboro', is £21,500. To liquidate this debt, a sinking fund of 10 per cent. is now proposed. The loan of £20,000 for water works is proposed to be raised on the same terms as the coal loan, by £100 debentures, bearing 8 per cent. interest, for which and for the principal (which is payable in thirty years), the revenue of the province is to be pledged.

APPLIED CHEMISTRY.

ON THE ASSAY OF THE ALKALOIDS IN MEDICINAL EXTRACTS, BY T. B. GROVES, F.C.S.—The object of the author was to devise a process for estimating the strength of the vegetable extracts used in medicine. The method he employed was a volumetric one. Mayer, of New York, and Valser, of Paris, had worked upon the same subject, and all three had fixed upon the same liquid for precipitating the alkaloid, namely, the iodohydrargyrate of potassium. All three also had suggested formulæ for the precipitate. Valser's experiments corroborated those of the author, while Mayer's pointed to a different conclusion. Mayer's experiments were then reviewed, and the details of some reactions given, from which it seems that, on adding the iodohydrargyrate to the solution of the alkaloid, a point was arrived at—the addition of either liquid caused a precipitate. In this way some of the apparent anomalies might be explained. If, however, time were allowed for the completion of the reaction, more definite results might be obtained. He described the reactions with strychnia, quinine, cinchonine, morphia, nicotina, and codeia, and reviewed Mayer's results, which were quite, he said, anomalous. In estimating the amount of alkaloid in an extract, the alkaloid must first be isolated as far as possible by Stas's well-known method. In estimating the medicinal value of an extract, more exact methods than those now known must be discovered before accuracy can be attained.

ANTI-CORROSIVE MIXTURE.—The *Zuricher Gewerbeblatt* recommends a solution of beeswax in benzoyle, to prevent steel from rusting. A thin coating of wax will stick to the object imbued with it, while the benzoyle evaporates.

ON THE DIFFERENCE BETWEEN ACTIVE AND ORDINARY OXYGEN, BY M. CLAUSIUS.—Some years ago M. Clausius put forth an hypothesis on the nature of ordinary and active oxygen or ozone bearing resemblance to previous hypotheses proposed by other chemists (notably MM. Favre and Silbermann, Gerhardt, and Brodie), and which he expresses in the two following propositions:—1. Ordinary oxygen is formed of atoms united in binary groups, active oxygen of isolated atoms. 2. The two atoms constituting a molecule of ordinary oxygen are in opposite electric conditions. To these two fundamental hypotheses are added the two following accessory hypotheses:—3. The two isolated atoms proceeding from the division of a molecule of ordinary oxygen immediately lose their positive or negative electricity and become neutral. 4. The atoms remaining isolated if a volume of ozone contains the same number of molecules as the same volume of some other simple gas, the density of the ozone should be half that of ordinary oxygen. The third hypothesis is hardly compatible with the existence of antozone, nor with the well-known property of ozone of exercising two opposite actions on oxygen held in combination. M. Clausius, moreover, thinks it better to abandon it. He consequently admits that ozone is formed of electro-negative atoms, and antozone of electro positive atoms; besides which he thinks it probable that the atoms of ozone constantly retain their electro-negative state, but that the facts as yet known do not authorise so precise a conclusion with regard to antozone. As to the fourth hypothesis, it has become absolutely inadmissible, since the recent experiments of M. Babo and M. Soret have established the fact that ozonised oxygen increases in volume in passing to the state of ordinary oxygen. To reconcile this remarkable phenomenon with his fundamental hypothesis, M. Clausius now supposes that the isolated atoms of active oxygen are able to unite by reason of a feeble affinity between binary molecules of ordinary oxygen; the density of the gas is thus augmented without sensibly diminishing the chemical activity proper to the isolated negative or positive atoms.

THE MORPHIA SALTS OF COMMERCE, BY MR. W. E. HEATHFIELD.—The inquiries of the author had been directed to the amount of moisture existing in these salts, and also to the question as to whether codeia was present in them. Three samples of hydrochlorate from different manufacturers had been examined, and found to contain, respectively, 5·8 and 9·8 per cent. of water, estimated by drying at 212°. The amount of alkaloid obtained from each of the above (dried at 212°) was 79·7, 76·7, and 74·3, the quantities thus varying inversely as the amount of water. It was noticed that the samples containing the most moisture dissolved more readily in water, and their solution were less coloured than those which were originally drier. Three samples of acetate were then examined in a similar way, and found to contain respectively 5, 10, and 12·6 per cent. of moisture. It was found that the sample containing least water fused and became dark coloured, with loss of structure on application of a water bath heat, while that containing the most water retained its pulverulent form unaltered at that temperature. The morphia precipitated from these samples was found to be remarkably pure, being perfectly soluble in caustic potash, scarcely acted on by ether, and almost entirely free from codeia, as were also the mother liquors from which they were separated. The author also quoted experiments by Mr. How to show that, however feasible the conversion of morphia into codeia might appear on a comparison of their formulæ, it could not be carried out; a substance isomeric with codeia had been obtained, but it was by no means identical.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent, Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of The Artizan."

Dated September 27th, 1864.

2361 J. Mackay—Projectiles
2362 W. Clark—Means of actuating electric dials or clocks
2363 J. Hill—Screens and sieves
2364 H. Bennison—Fluid meters
2365 R. S Bartlett—Needles, and in machinery used in their manufacture
2366 H. C. Symons—Sewing machines, and means of giving motion thereto
2367 A. J. Adams—Door locks
2368 W. H. Orth—Furniture
2369 G. B. Cornish—Applying metal sheathing to iron or steel ships
2370 R. A. Brooman—Petticoats
2371 J. P. Harris—Breech loading fire arms
2372 I. Parkes—Shears for cutting metal
2373 K. H. Lane—Receptacles for photographs
2374 J. C. Wilson—Pumps

Dated September 28th, 1864.

2375 J. Lister—Theodolites, levels, and other instruments
2376 H. Forbes—Steering ships
2377 C. J. W. Machon—Crinolines, and in the machinery connected therewith
2378 G. Davies—Application of thin strips of wood for various purposes
2379 T. Powell—Ovens for baking
2380 W. Whitehead—Looms for weaving
2381 W. Clark—Fastenings for purses, boxes, and other articles
2382 A. Pemberton & J. Ford—Apparatus for effecting the drag in throstle spinning
2383 J. Jongen—Fire-arms
2384 J. Weems & W. Weems—Engine governors, and apparatus for indicating and regulating the flow of fluids
2385 N. Thompson—Stoppers
2386 H. A. O. Mackenzie—Rollers and wheels for drawing fibrous materials
2387 T. J. Denne—Protecting the sides and bottoms of iron ships
2388 C. W. Allen—Communicating between passengers and guard of a railway train
2389 A. Normandy—Cooking apparatus

Dated September 29th, 1864.

2390 J. Schneuhr—Counting coins, and indicating the number thereof
2391 A. Cuthell—Slide and cut-off valves for steam engines
2392 W. Crowther—Opening and cleaning cotton
2393 C. Defries—Lighting and ventilating
2394 J. Watts—Fermentation of worts and other fermentable liquids
2395 S. Alley—Rachet drilling braces and screw keys
2396 G. Haseltine—Breaking and grinding minerals and other hard substances
2397 G. Haseltine—Labels or tags for cotton or other bales
2398 T. Bennett—Kilns for burning quarries, bricks, and other articles
2399 G. Allix—Reefing sails
2400 R. A. Brooman—Printing cylinders
2401 G. Lindsley—Break blocks
2402 G. H. Harrington, H. Hewetson, & F. Y. Hewetson—Threads and yarns

Dated September 30th, 1864.

2403 H. C. Hurry & E. Wilson—Rifles and other small arms
2404 W. F. Henson—Railway carriage, buffer, and other springs
2405 J. Vine—Giving buoyancy to, with facility for, the propulsion of ships
2406 J. T. Pendlebury—Ginning cotton
2407 A A. Croll—Treatment of sulphate of alumina
2408 H. J. Keer—Ladies' boots
2409 C. G. Gumpel—Surgical appliances for supporting parts of the human body
2410 W. H. Graveley—Steam machinery and sea water distilling apparatus
2411 R. A. Brooman—Rendering soluble different colours in crystals derived from aniline and phenic acid
2412 J. Jennings—Mounting rotary hair brushes
2413 J. Johnson—Decomposing common salt with sulphuric acid
2414 W. E. Newton—Embossing collars and other articles from paper
2415 W. Clark—Vehicles

Dated October 1st, 1864.

2416 R. M. Hands—Dressing yarns and threads of silk
2417 J. S. Grimshaw—Looms for weaving
2418 P Winton—Reaping machines
2419 E. O. Greening & J. Greening—Fences and similar articles of wire
2420 E Loysel—Obtaining extracts from tea and other vegetable substances
2421 H. Druce—Ladders
2422 J. H. Johnson—Coating and flocking fabrics
2423 F. N. Gisborne—Working electric signals for gunnery practice
2424 W. Clark—Twisted silk
2425 W. H. Beaumont—Sack holder and truck or cart combined

Dated October 3rd, 1864.

2426 W. E. Gedge—Hinges
2427 L. Cashmore & C Cashmore—Needles employed in knitting machinery
2428 R. A. Brooman—Substitute for albumen
2429 S. Bateman—Brakes for railway carriages
2430 W. S Cowles—Casks to retain petroleum and like fluids
2431 G. T. Bousfield—Separating coir fibre from the husk of the cocoa nut

Dated October 4th, 1864.

2432 R. Laming—Ammoniacal preparations
2433 J. H. Johnson—Transmitting motive power, and in the machinery employed therein
2434 C. Shether—Fastenings for purses and other articles
2435 T. K. Callard—Ventilators
2436 H. J Standly & W. Prosser—Welding iron and other metals
2437 G. Haseltine—Steam engines
2438 T. A. Swinburne—Reefing and furling of ships' sails
2439 E. Davies—Screw threads
2440 T. Dobson—Manufacture of bricks and similar articles
2441 A. Monro—Steam boilers
2442 G T. Bousfield—Harvesting machines
2443 J. Johnson and T. Johnson—Purifying resinous substances
2444 C. H. Reid—Preventing leakage of the tubes of tubular boilers
2445 C. Greenway—Railway turn-tables

Dated October 5th, 1864.

2446 H. A. Bonneville—Locks, and other means of closing doors
2447 E. Davies—Forging and shaping articles of iron
2448 J. H. Johnson—Muffles employed in the manufacture of mirrors
2449 J O. Communay—Affixing handles to shovels and spades
2450 G H. Castree—Looms for weaving
2451 B. J. Bromwich—Obtaining and applying motive power
2452 H. Conant—Winding threads on bobbins or spools

Dated October 6th, 1864.

2453 T. Brown—Ventilating
2454 J. W. Gibson—Slide valves of steam and other engines
2455 E. T. Hughes—Looms for weaving
2456 F. Tolhausen—Transmitting signals
2457 C. L. Oliver—Brushing the hair
2458 T. Turner—Breech loading fire-arms
2459 E. V. F. Huntzinger—Sea compasses
2460 B. Margulies & J. K. Leather—Manufacture of salts of chromium
2461 W. Anderson—Working railway signals
2462 H. Nelson—Pressing cotton
2463 F. W. Shields—Telegraphic posts
2464 P. A. Le Comte de Fontainemoreau—Machinery for propelling
2465 P. A. Le Comte de Fontainemoreau—Photography

Dated October 7th, 1864.

2466 W. Stevens—Cultivation of the land by steam power
2467 J. P. Turner—Metallic buttons
2468 T. Parkins—Prussiates of potash
2469 A. Muir—Breech-loading fire-arms
2470 W. Clark—Preparing or treating vegetable fibrous materials
2471 G. Davies—Oiling wool
2472 G. Haseltine—Process for purifying coal and ores
2473 C. Chapman—Life-boats
2474 E. Allen—Driving bands and chains
2475 T. Kenyon—Preparing and fixing cloths and yarns
2476 R. S. Prowse, H. Duke, & T. Clayton—Ordnance and small arms
2477 H. Kemp & F. J. Kemp—Hardening leather for boot soles
2478 A. Jackson—Constructing and arming ships or vessels
2479 R. E. Donovan, M. O'Farrell, & F. O'Farrell—Rolling and twisting tobacco
2480 W. E. Newton—Projectiles
2481 H. S. Coleman & A. G. E. Morton—Cultivation of land by steam power
2482 G. N. Boston—Fire-arms
2483 R. M. Hands—Dressing and lustring threads and yarns
2484 J. G. Beckton—Heating retort and other ovens
2485 W. Gardner—Defiance fire and thief proof safe
2486 C. H Collette—Magneto-electric machines
2487 J. Cassell—Treating coal and ligneous products and in obtaining fuel, oil, and other products therefrom
2488 S. Vaile—Propelling ships
2489 T. Shorey and J. Bell—Reefing sails
2490 J. Lutchart & H. Strond—Reefing sails
2491 E. L Nicholas—Book-binding
2492 J. Webster—Flat chain
2493 H. T. Wedlake & F. J. Kitsell—Organ pipes
2494 E. H. Hueb & F. Winebausen—Obtaining motive power
2495 T. Lambert & H. C Soper—Taps or valves
2496 J. Collinge—Woven fabrics

Dated October 11th, 1864.

2497. J. I. Vougban—Resins and resinous substances
2498. B. H. Jones—Facilitating locomotion
2499. M. Gillingbam & T. Gillingham—Boking apparatus
2500. W. Gilbert, E. Cooper, & G. R. Webster—Alarm in case of fire
2501. G. H. Reay—Envelope machines
2502. T. Adams & G. J. Parsons—Slide valves
2503. J. W. Nottingham—Lighting fires
2504. H. Tucker—Bronze colouring iron
2505. H. L. Kolzewsky & A. Wilson—Preparation of jute and other fibrous substances
2506. W. E. Newton—Manufacture of ink
2507. G. Coles, J. A. Jacques, & J. A. Fanshawe—Manufacture of bogs, sacks, pouches, and other flexible articles of capacity
2508. W. B. Haigh & S. Barlow—Machinery or apparatus for spinning and doubling cotton and other fibrous materials
2509. F. Watkins—Railway carriages
2510. F. Wilkins—Apparatus for the production of hydro-carbon vapour for illuminating or heating purposes

Dated October 12th, 1864.

2511. J. Moller—Manufacture of colouring matter for marking ink
2512. L. G. Loiseau—Railway signal apparatus
2513. I. Williams—Sabre revolver
2514. J. G. Taylor—Dress fastenings and ornaments
2515. J. Slater—Toothed chains for working toothed or chain wheels
2516. R. Story—Manufacture of india-rubber or caoutchouc threads
2517. J. V. Jones & G. J. Williams—Manufacture of cornice poles
2518. M. J. Rice—Pneumatic apparatus for communicating between passengers and guards in railway trains
2519. R. K. Inman—Embroidering shirt fronts

Dated October 13th, 1864.

2520. M. A. F. Mennons—Machinery for applying pressure to the rolling and drawing of metals
2521. A. S. Paterson—Nut and lobster crackers
2522. E. Moride—Treatment of sea wrack grass, for the extraction of carbon and salts
2523. F. Noble—Machinery for raising and applying water and other fluids
2524. L. Clauss—Ornamenting articles of china, earthenware, and other materials
2525. J. Watson—Manufacture of hydro-carbons
2526. R. A. Brooman—Manufacture of prussiates of ammonia, and the application of prussiates of ammonia to dyeing, printing, and photography
2527. M. Henry—Steam machinery for rolling roads or ways
2528. J. Robbins—Machinery for driving and drawing piles
2529. J. T. Cook—Battens for weaving
2530. J. Baikin—Bean slicer

Dated October 14th, 1864.

2531. J. Cooke—Catches or fasteners which may be adapted to portable or pocket ink-bottles
2532. W E. Gedge—Power-looms for weaving
2533. W. R. Sykes—Apparatus for transmitting positive and negative currents of electricity
2534. A. Hippins—Construction of stoves for heating purposes
2535. J. Watts—Apparatus for conducting the fermentation of wort and other fermentable liquids
2536 L. J. Crossley—Electric telegraphs
2537. P Meunemans—Railway waggons and carriages
2538. R. Wright—Preparing saccharine matters
2539 J. H. Dallmeyer—Photographic lenses
2540. O. L. Hopson and H. P. Brookes—Pointing wires or rods for pins and other articles
2541. W. Clark—Apparatus for lubricating
2542. W. H. Kelsey—Chimneys and flues for houses

Dated October 15th, 1864.

2543. J. H. Brierley—Ladies' waist buckles
2544. J. Sarberton—Cure for smoky chimneys
2545. F. Robinson, G. Washington, and G. Smith—Apparatus for drying or dessicating materials or substances containing moisture
2546. G. Davies—Economising the manufacture of useful articles of leather
2547. J. Huyes—Sewing machines
2548. W. E. Newton—Pumps.
2549. H. Mason—Cop or tube frames employed in spinning and twisting fibrous substances
2550. F. Wise—Boilers for the generation of steam
2551. E. Baines—Apparatus for reefing and furling ships sails
2552. W. Clark—Preparation of artificial wax
2553. T. Raudle—Eradication of corns, bunions, worts, and excrescences on the hands or feet
2554. E. Tomlinson and J. Jones—Apparatus for breaking the husks of cotton pods, and opening and separating the cotton from the same previous to ginning

Dated October 17th, 1864.

2555. F. A. Calvert—Engines for obtaining motive power
2556. A. D. Dhe—Envelopes
2557. C. T. Judkins & W. H. Gosling—Machines for sewing button holes
2558. T. Corbett—Signals or alarums
2559. A Hill—Improvements in privies, dry closets, and commodes
2560. J. Cassell—Carburation of gas and atmospheric air
2561. J. Bruce—Fabric suitable for sail cloths, awnings, and tarpaulins
2562. M Henry—Apparatus for reducing the friction of moving parts of carriages, engines, machinery, and apparatus
2563. J. Brownhill—Manufacture of feet casts, and lasts for boot and shoe making
2564. J. Maurice—Method of producing optical illusions in theatres
2565. W. E. Newton—Marine steam boilers
2566. W. E. Newton—Safety fuzees for blasting

Dated October 18th, 1864.

2567. A. Paul & E. Paul—Hydraulic rudder break
2568. S. Howard & W. Wood—Reefing and furling sails
2569. J. Zeh—Moving or mechanical grates, or fire-bars
2570. J. Hart—Reefing fore and aft sails
2571. J. Reid—Water wheels, paddles for propelling vessels, water pumps, and chains
2572. J. Macdonald—Carriages
2573. N. Thompson—Stoppers for bottles, jars, and other vessels, and for the muzzles of fire-arms
2574. C. Pettit—Corrugating, fluting, or fashioning metal sheets with irregular surfaces
2575. W. E. Newton—Chronometers
2576. J. Johnson—Composition for renovating silk, satin, stuff, woollen cloth, silk, beaver, or felt hats, cotton, and other fabrics
2577. J. Ludwig—Setting or securing stones for jewellery
2578. W. Clark—Presses for compressing substances for baling
2579. J. C. A. Henderson—Ladies' skirts
2580. W. Gilbert and F. Gilbert—Hafts or handles for spring knives

Dated October 19th, 1864.

2581. W. Taylor, H. Harrison, & G. Brown—Manufacture of iron
2582. W. M. Ryer—Conveying and exploding submarine explosives
2583. W. Buxton—Preparation of sheep's wool for medical purposes
2584. G. Hartley—Covering busks for stays and bodices
2585. T. Turner—Breach-loading guns
2586. A. Clavel—Supporting glasses, shades, and reflectors used with lamps and burners
2587. J P. Horriss—Projectiles and sabots for projectiles

Dated October 20th, 1864.

2588. T. P. A. Key—Fastening armour plates to vessels of war
2589. F. Walters—Penknife and pocket knife blades
2590. W. Snell—Breech loading fire-arms
2591. M. Gandy—Reefing and furling the square sails of navigable vessels from the deck
2592. W. H. Ablett & J. Borlase—Manufacture of woven fabrics
2593. J. Shaw—Coffer dams, apparatus to be used therein, and in sinking cylinders and tanks for making foundations under water
2594. L. H. G. Ebrbordt—Gunpowder
2595. Charles Brothers—Extinguishing fires
2596. W. E. Stevens—Rotary engines
2597. R. A. Brooman—Apparatus for registering and indicating the distances travelled by and the rate of travelling of cabs and other vehicles, and the time they have been engaged
2598. W. L. Tizard—Brewing and distilling, and separation of liquids from solids
2599 W. Hall—Barrels for gunpowder
2600. W. H. Harfield—Capstans, windlasses, and
2601. J. Whitley—Railway wheels
2602. G. Davis—Fire-arms and cartridges

Dated October 21st, 1864.

2603. J. E. A. Gwynne—Construction of centrifugal machinery, applicable to pumps, fans, turbines, and similar apparatus
2604. F. Martin—Anchors
2605. L Paviola—Anti-salt coating for boilers of marine engines
2606. C. H. Gardner & C. English—Apparatus for stamping, applicable to postal and other purposes
2607. A. Reynolds—Sulphuric acid
2608. H. Wilson—Machinery for moulding and planing wood
2609. S. Westwood and H. Broodburst—Breach-loading fire-arms
2610. G. Davies—Buttons
2611. T. Allcock—Metal cornice and other poles and rods and mouldings for various purposes of utility and decoration
2612. G. E. Donisthorpe—Getting coals and other minerals
2613. J. F. Jones—Getting coals, stone, and other minerals
2614. G. F. Donisthorpe—Obtaining grease from wash waters
2615. R. Hornsby—Reaping and mowing machines

Dated October 22nd, 1864.

2616. J. Scarisbrick—Apparatus for signalling on railway trains
2617. A. Muir—Screw presses for compressing cotton and other substances
2618. H. Bird—Apparatus for stopping locomotive steam engines and railway carriages by the application of steam power to the working of railway breaks
2619. W. O. Walbrook—Printers' composing frames and cases
2620. G., G. W., & J. Betjemann—Cases or receptacles for matches, stamps, cards, and other articles
2621. J. Sonrd—Barring drags
2622. W. Pitts—Projectiles for artillery
2623. W. Richards—Cannon and other cartridges, and fire-arms
2624. J. Emary—Capes, paletots, overcoats

Dated October 23rd, 1864.

2625. A. Muir—Differential motion applicable to screw jacks, screw bears, and punching machines
2626. E. B. Colley—Propellers
2627. S S. Anderson—Manufacture of bricks, tiles, and other articles from plastic substances
2628. R. Hookham—Powder magazines for storing or keeping gunpowder or other explosive materials, and vessels and vehicles for transporting explosive materials
2629. G. Scheorb—Rotary engine actuated by the double action of steam or any other moving fluid
2630. J. Smith—Battens, and gear for communicating the to and fro motions to the driving planks of battens
2631. J. W. Scott—Means of attaching buttons to garments
2632. R A. Brooman—Apparatus for consuming smoke in steam boiler and other furnaces and fire-places
2633. H. Bateman and E. G. Garrord—Pumps
2634. W. Clark—Apparatus for concentrating and distilling sulphuric and other acids
2635. G. T. Bousfield—Apparatus for the manufacture of aerated bread

[redacted] is not to be overlooked; yet is that argument met by a [redacted] found in the "Records of Hale,"

at Liverpool; but inasmuch as ... is not known, the actual height reached can only be ascertained by a series of observa-


RIVER MERSEY,
WITH PLAN OF BREAKWATER AS PROPOSED BY C.RENNIE ESQ.C.E.F.R.S.
COUNTY OF LANCASTER
COUNTY OF CHESTER
FORMBY HALL
SEPHTON HALL
FORMBY OLD TOWN
RIVER ALT
INCE HALL
EAST LANCASHIRE RAILWAY
LEEDS AND LIVERPOOL CANAL
WALTON
LIVERPOOL CROSBY AND SOUTHPORT RAILWAY
EARL SEFTON
EARL DERBY
FORMBY POINT
LIFE BOAT HOUSE
LITTLE CROSBY
GREAT CROSBY
LIVERPOOL
EARL SEFTON
OTTERS POOL
DEVILS BANK
MIDDLE POOL
EASTHAM SANDS
RIVER MERSEY
MAD WHARF
OLD FORMBY CHANNEL
JORDAN BANK
FORMBY WHARF
CROSBY CHANNEL
ROCK LIGHT HOUSE
BATTERY
NEW BRIGHTON
LISCARD
BIRKENHEAD
ROCK FERRY
BROMBRO POOL
EASTHAM
BROMBOROUGH
TRANMERE
BIRKENHEAD & CHESTER RAILWAY
LOWER BEBINGTON
WALLASEY
WALLASEY POOL
GREAT FLOAT
THE PARK
BRAZIL BANK
BURBO BANK
TAYLOR BANK
FORMBY FLATS
LITTLE BURBO
ROCK CHANNEL
LEASOWE CASTLE
BIDSTON
SCALE OF STATUTE MILES.

W SMITH DE

tions with the spirit level. Assuming, however, that all resistance be removed, the greatest difference of level which could be attained by those particles of water entering the estuary with a velocity of 6·3 nautical, or 7¼ geographical miles, which corresponds to a velocity of 10·64ft. per second, would be

$$H = \frac{V^2}{2g} = \frac{\overline{10 \cdot 63}^2}{64} = 1 \cdot 76\text{ft.}$$

But inasmuch as the greatest velocity of influx occurs not at the high tide but at the half-tide level, after which the velocity of the current decreases very rapidly—considering, also, the tortuous course of the bed of the Mersey, which affords ample ground for inference that the retarding causes are very considerable—there is little ground to believe that there ever was or could be any very material difference between the high tide levels of the two points in question; and the 1ft. difference given by Giles's Survey certainly appears to be the utmost that could be attained.

The hypothesis, however, might be made that the tidal waters upon entering through the Seacombe Narrows meet the inland waters by impact, these latter being at the time in a state of rest; and in this case, according to the well-known principle of *hydraulic pressure* or *fluid impact*, first demonstrated by Newton, the tidal waters should be able to hold in equilibrium a head of water double that which would produce the velocity of motion with which they enter the estuary. Under this hypothesis, therefore, supposing the maximum velocity of 7¼ miles to be sustained during the whole of flood, and assuming that no losses occur through imperfect impact, a difference of level of 3·52ft. could be attained.

The assumption, however, of the perfect impact of two fluid masses, which meet without the interposition of a solid diaphragm, is inadmissible, while the hypothesis of a uniform velocity of motion throughout the period of flood is contrary to known facts; and on these grounds it becomes obvious that a considerable reduction must be made from the theoretical difference of level which could be attained under this hypothetical, though very improbable state of things.

Yet, upon looking over diagram Fig. 3 Plate 269, of the longitudinal section of the river as defined by the survey of Mr. Graham H. Hills, acting under Lieut. Murray T. Parkes, it will be seen that a difference of 4ft. has there been recorded between the high tide levels at Liverpool and at Warrington; and in their joint report upon this survey these gentlemen premise that in comparing the same with Giles's they discovered an error in his levels, arising from a wrong assumption of the general incline of the country between Liverpool and Warrington, which, having corrected, they were enabled to establish the comparison of depths as shown in the diagrams. Such an extraordinary difference of levels might perhaps be accounted for by the prevalence of strong north-westerly winds during the whole of the period required to take the observations, in which case it would be a purely accidental occurrence, which should not be placed on record as a normal condition of things. This hypothesis, however, again appears very unlikely; and as the circumstance cannot be explained by any known scientific principle, the only conclusion remains that Mr. Hills's high water levels are entirely incorrect.

It is proper to remark here that Capt. Denham's Survey, already published, shows all high tide levels throughout the tidal reach to correspond with the hydrostatic levels of high tides at Liverpool.

Reverting now to the parliamentary inquiry which has led to the above inquiry into high tide levels, it may here be observed that there was a certain amount of truth as well as of error in the arguments of both the advocates and the opponents of the Birkenhead Dock scheme.

It was true enough, as was argued by Mr. Rendel, that a portion of the proposed works at Birkenhead, together with the intended prolongation of the river wall at Liverpool, would have a tendency to modify the direction of the current of flood-tide, and would be conducive to an increased velocity of influx. It was true also that, in this case, there should be an increase of the tidal reach, and, consequently, of the volume of water entering the estuary upon each flood; but it was doubtful and very unlikely that any such increase of velocity would be obtained as could actually replace the quantity of water abstracted by damming up Wallasey Pool. With regard to the first proposition, it is satisfactory to find, as shown in a previous paper, that, as affecting Pluckington Bank, Mr. Rendel's prediction has proved correct, while, as touching the velocity of tides, it is found by comparing the rates given in the table which accompanied our last paper with those given by Capt. Denham, that an increase of half a mile of greatest velocity of flood, and of a quarter of a mile of greatest velocity of ebb, has been realised.

On the other hand, it was very true, as argued by Mr. Rendel's opponents, that by the abstraction of the waters of Wallasey Pool from the daily flux and reflux, the sea channels were deprived of so much of the then available scouring power; and seeing how small are the sectional areas of those portions of the river which Messrs. Parkes and Hills have very aptly designated as the tidal breakwater, it was reasonable to suppose that no rise in the high tide level that could be obtained by an increased velocity would compensate for that abstraction, since such a rise does not imply a similar condition in the high tide levels of the entire tidal area, but implies simply that the upper portions of the tidal wave have been impelled so much further up the incline of the river bed. An increase of half a mile in the velocity of flood shows a calculated rise of 2·76in. in the high tide level at the extreme end of the tidal reach, which for a mean width of channel of half a mile would have to establish itself over a distance of upwards of 31 miles to compensate for an abstraction of 3,750,000 cubic yards; or, practically speaking, the tidal level would have to be raised 2·76in. over the entire area of the tidal reservoir proper.

At this distance from the days when the Birkenhead Dock scheme was matured, it would be impossible for us to follow the opponents of that project through their work of opposition with the same feeling with which they pursued it, even if we did not know that, as regards the scour of the sea channels and keeping them open, the experience so far realised has, in a general way, proved itself favourable to Mr. Rendel's views; for we have mentioned already that the depth of water on the bar has increased by 2ft. since Capt. Denham published his Survey. Neither would this be a fit and proper place to enter into a controversy which originates in and resolves itself into a purely commercial question; but it may not be without interest to point out the error committed by the managers of the Dock Estate in attempting to defeat that project by taking their stand upon purely technical ground.

By the generally accepted principles of birthright in this country, the merchants of Liverpool had a just and perfect claim to precedence in the construction of any works that might be required for the interests of the port They were, on that very ground, the lawful conservators of the harbour, and the interest which they had in its continued prosperity were such as would at all time lead them to do that which would be most conducive to that object. It appears to us, therefore, that for these reasons had they been prominently urged by the Dock Committee, the Legislature should have decided in their favour, rather than authorise the construction of works which at a later date burdened the Mersey Dock Estate with financial obligations of a most serious nature.

The technical impeachment set up was entirely lame, as has been proved by facts; and as is too well known, it proved a failure. We shall, however, take occasion to refer to that parliamentary inquiry again, when treating of the Birkenhead Dock Works in detail.

It has been shown that from the very birth of this gigantic establishment, and in particular since the beginning of the present century, when, in consequence of the increase of trade, it developed itself with such wonderful rapidity, the best known engineering talent was employed, not only in the construction of docks and the providing accommodation to goods and merchandise, but more especially for the purpose of devising means and measures for the preservation, and, if possible, the improvement of the estuary and of its sea approaches: Giles's Survey of 1819, followed by Whidbey's, Rennie's, and Giles's reports of later dates, all testify to the truth of this statement; and no one will suspect that by these

gentlemen the question at issue has been dealt with, rather as being a Birkenhead question, or as being a Liverpool question, but simply as one affecting the estuary of the Mersey. If, therefore, it be shown also that the managers of the Dock Estate have endeavoured to carry out the advice at various times tendered to them, so far as their means enabled them to do, that fact will clear them from the imputation of selfishness in their opposition to the Birkenhead Dock scheme under a rival company, and will, moreover, verify the assertion made in our introductory paper, that "there has been an unswerving consistency of purpose from the earliest days of this undertaking, to make the best use of the natural means at command."

It has already been stated that all dock extensions, or at any rate the greater portion of them, have taken a northerly direction towards the mouth of the river, because the engineering profession had recommended in general terms the construction of a river wall, in order by it to guide the tide, and to ensure a more efficient scour. The Dock Committee, however, do not appear to have been wishful to trust to their own wisdom in the interpretation of this general advice, received at a somewhat early date; but in 1850-1, when the requirements of the trade demanded further dock accommodation, they again employed Mr. George Rennie to report to them on that subject, and the suggestions then made by him, which are illustrated in Plate No. 270, are as follows:—

1st. The construction of a jetty or breakwater projecting from Rock Point at the entrance of the Mersey on the Cheshire shore, in a line nearly parallel to the Lancashire shore; the breakwater to take a north-westerly direction, and curve outwards towards the Victoria Channel across the Brazil and Burbo Banks for a distance of upwards of three miles, there to be terminated by a lighthouse.

2nd. Simultaneously with the construction of the breakwater to continue the line of quay wall in a direction curving inwards as far as Formby Point, so as to assimilate the form of the entrance to a trumpet's mouth.

The advantages which this plan proposes to realise are thus enumerated by Mr. Rennie:—

1st. The general improvement of the entrance into the harbour, by which the flow and ebb of the tides will be more regular and more favourable to the deepening and preserving of the low water channels, and to their navigation generally.

2nd. The protection of the north docks, which are occasionally inaccessible in stormy weather, and of the Bootle and Formby shores, from the violent effects of the prevailing winds.

3rd. The acquisition of nearly 2,000 acres of valuable land, which will be enclosed between the new wall and that shore.

4th. The probable conversion of from thirty to forty thousand acres of sandbanks, now rapidly accumulating and rising above low water along the whole shore in front of the Leasowes, from the Rock point to the entrance of the Dee estuary at Hilbre Point.

5th. The prevention from entering into the harbour of vast quantities of drift sand which comes from the North Burbo Banks in south-westerly gales.

6th. The prevention of many shipwrecks, and loss of lives and property which occur annually.

7th. The reduction to a minimum of the great expenses now incurred in maintaining the lights, buoys, steamtugs, dredgers, &c., employed in preserving the direction and depth of the sea channels.

Finally. The preservation and improvement of the port and harbour of Liverpool, which, like its neighbour the estuary of the Dee, will be entirely ruined if prompt measures be not taken to prevent it.

With regard to the first part of this scheme, namely, the breakwater which it is proposed to form, in prolongation of the Cheshire shore, it may at once be said that, whatever be its prospective advantages in the shape of protection afforded to the North Docks against heavy storms, and increase of scouring power to the main sea channels, the Board of Trade are not likely ever to become consenting parties to the voluntary sacrifice of the Horse and Rock Channels, even if it could be clearly shown that such a construction would bestow a material and permanent benefit upon the Crosby and Victoria Channels; and there could not be the remotest doubt that the proposed work, if carried out, would at once doom the former, by depriving them of their share of the scouring power of the ebb tide. This event, of course, was foreseen by Mr. Rennie, since be anticipates the entire reclamation of some 40 square miles of sandbanks across which these channels take their course. It is, difficult, however, to conceive on what ground such a result could be looked for, seeing that an embankment of two or three miles in length had to be constructed at Wallasey Leasowes, in order to reclaim permanently some 3,000 acres of low lands, which were formerly overflowed by the tidal waters during the high tide periods—a circumstance which gives fair ground for inference that the banks outside could not be reclaimed without the previous construction of a permanent enclosure in the shape of an embankment running parallel to the present line of shore, between the Rock and Hilbre Points. The bill, moreover, which the landowners of Lower Wallasey and Wallasey Leasowes pushed through Parliament during the last session, seems to us to furnish proofs sufficient that such an undertaking is not likely ever to be carried out, for in the preamble of that bill the landowners (and among them Mr. Whyner) pleaded—

1st. That the lands which were protected by the said embankment were so utterly poor that they did not pay their working expenses, and consequently that the owners could not be expected to pay their then quota towards the expenses of keeping that embankment in repair.

2nd. That, although the embankment was of no use to them, yet was it required as a protection to the Rock and Horse Channels, in order to prevent them silting up, and to keep them open to the navigation.

3rd. That these channels were of such vital importance to the trade of the port, that it would be highly injudicious to allow them to deteriorate, and that for these reasons the Mersey Docks and Harbour Board, being the real parties interested in the maintenance of that embankment, should defray the expenses of keeping it in repair.

Of these various propositions they succeeded in convincing the committees of the two Houses of Parliament, who ratified their bill in all its points, and thus indirectly affirmed the statement above made, that no parliamentary enactment ever would sanction the voluntary blocking up of the Horse and Rock Channels.

It is, of course, not to be inferred here that we share in the belief that those various propositions are true; and though it forms no part of our work to enter into any argument respecting them, yet may we state that, in our opinion, the first is greatly exaggerated. As to the second, if it be granted, it carries with it the conclusion that the Mersey Docks and Harbour Board should protect the entire line of coast, of which this embankment forms a part, by means of a permanent structure of a similar character, since the whole is composed of sandhills, which are gradually being wasted away by the action of the sea; and if such a responsibility be saddled on the shoulders of that body, it is difficult to know where their responsibilities will end. We have, however, entered into this subject thus at length, and shown what Parliament has done, in order to enable the reader to satisfy himself that there is no probability whatever of the first portion of Mr. Rennie's scheme ever becoming a reality.

The second portion of that scheme, namely, the extension of the north wall on the Lancashire shore, was of more immediate importance to the Mersey Docks Board; 1st, because its special functions are to regulate the flow of the tide, and to improve the chances of keeping open the estuary proper; 2nd, because its construction at once supplied comparatively cheap ground upon which to build the docks required to accommodate the continually increasing trade of the port. This portion of the scheme, therefore, the Docks Board have carried out to that extent, at any rate, as the want of increased dock accommodation has required it; and when that portion of the work which is now in progress is completed, about one-half of the length of wall proposed by Mr. Rennie will have been constructed.

COMPARISON OF DEPTHS AND OF AREAS OF SECTIONS OF THE MERSEY IN 1819—22 WITH 1861.

Reference to Locality of Sections.	Depths. Distinguishing Numbers of Sections arranged according to their Depths in 1861, as compared with 1819—22.			Areas of Sections, &c., in Square Yards.					
	Increased.	Unchanged.	Decreased.	1819—22.	Amount affected by Enclosure since 1822.	1819—22. Reduced by Enclosure.	1861.	Increased.	Decreased.
1st.									
New North Dock Wall	...	3	...	41,250	4,300	36,950	36,350	...	600
	5	...	...	41,750	4,000	37,750	37,300	...	450
	7	...	...	42,850	3,950	38,900	39,150	250	...
	9	...	...	41,500	4,300	37,200	38,900	1,700	...
	11	...	...	37,800	4,100	33,700	33,800	100	...
	13	...	...	34,050	4,300	29,750	30,750	1,000	...
	...	15	...	32,850	3,800	29,050	27,250	...	1,800
	17	...	...	27,100	1,300	25,800	26,300	500	...
Clarence Dock	19	...	...	25,600	1,850	23,750	24,950	1,200	...
Seacombe Point	...	...	21	23,700	1,550	22,150	21,900	...	250
Wallasey Pool, &c.	23	...	...	24,450	2,800	21,650	23,100	1,450	...
Prince's Wall	25	...	...	26,100	1,500	24,600	25,400	800	...
2nd.									
Wallasey Pool	26	...	...	...	...	...	...	...	...
Pluckington Bank.	...	27	...	27,600	2,400	25,200	25,400	200	...
	...	...	28	...	...	...	...	...	...
	29	...	...	26,400	600	25,800	26,800	1,000	...
	...	...	30	...	...	...	...	...	...
	...	31	...	28,050	350	27,700	27,200	...	500
	32	...	...	...	...	...	...	...	...
	33	...	...	28,450	...	28,450	29,200	750	...
	...	34	...	...	...	...	...	...	...
	35	...	...	31,900	...	31,900	31,900	...	...
	36	...	...	...	...	...	...	...	...
Brunswick Dock	...	...	37	31,000	1,600	29,400	30,950	1,550	...
	...	...	38	...	...	...	...	...	...
	39	...	...	30,300	500	29,800	29,550	...	250
Harrington Dock	...	...	40	...	...	...	...	...	...
	41	...	...	30,550	650	29,900	31,600	1,700	...
	...	...	42	...	...	...	...	...	...
	43	...	...	30,950	600	30,350	32,700	2,350	...
	45	...	...	32,950	500	32,450	32,100	...	350
	46	...	...	...	...	...	...	...	...
Dingle Point	...	47	...	35,000	...	35,000	33,400	...	1,600
3rd.									
	...	...	49	37,950	...	37,950	37,200	...	750
	...	...	50	...	...	...	...	...	...
	...	...	51	35,100	...	35,100	38,650	3,550	...
	...	...	52	...	...	...	...	...	...
Otter's Pool	...	...	53	39,450	...	39,450	39,150	...	300
	54	...	...	...	...	...	...	...	...
	...	...	55	39,650	...	39,650	38,000	...	1,650
	56	...	...	...	...	...	...	...	...
	57	...	...	38,500	...	38,500	38,650	150	...
	...	58	...	...	...	...	...	...	...
	...	...	59	41,200	...	41,200	43,150	...	1,950
Easham and Garston	60	...	...	...	...	...	...	...	...
Garston Dock	...	...	61	41,900	600	41,300	40,950	...	350
	...	...	62	...	...	...	...	...	...
	63	...	...	40,550	...	40,550	38,600	...	1,950
	...	64	...	...	...	...	...	...	...
	...	...	65	36,900	...	36,900	39,750	2,850	...
	66	...	...	...	...	...	...	...	...
	67	...	...	...	...	...	...	...	...
Speke and Netherpool	68	...	...	33,850	...	33,850	35,850	2,000	...
Ellesmere	...	70	...	...	...	...	...	...	...
	71	...	...	36,150	...	36,150	39,600	3,450	...
Dungeon Point	74	...	...	30,100	...	30,100	30,200	100	...
	76	...	...	...	...	...	...	...	...
	...	...	77	26,400	...	26,400	26,450	59	...
	...	80	...	19,050	...	19,050	20,350	1,300	...
	...	...	81	...	...	...	...	...	...
Hale Head	...	...	82	...	...	...	...	...	...
4th.									
Hale & Frodsham Marsh	...	...	83	13,250	...	13,250	11,050	...	2,200
	...	84	...	...	...	...	...	...	...
	...	86	...	...	...	...	...	...	...
Weston Point Church	...	...	87	...	...	...	...	...	...
	...	...	89	7,050	...	7,050	7,100	50	...
	...	...	90	...	...	...	...	...	...
Duke's Dock	96	...	...	7,250	...	7,250	5,450	...	1,800
	98	...	...	5,850	100	5,750	4,750	...	1,000
	...	...	100	...	...	...	...	...	...
Runcorn Ferry	105	...	...	...	...	...	...	...	...
	...	...	106	2,750	...	2,750	2,400	...	350
	...	...	107	...	...	...	...	...	...
Wood End	111	...	...	...	...	...	...	...	...
	...	112	...	5,350	...	5,350	4,750	...	600
	...	...	114	4,950	...	4,950	4,250	...	700
Halton Point...	...	...	118	3,200	...	3,200	3,200	...	...
	...	121	...	2,650	...	2,650	1,850	...	800
	122	...	...	1,700	...	1,700	1,350	...	350
	123	...	...	...	...	...	...	...	...
Sir R. Brookes' Pier	124	...	...	1,250	...	1,250	1,250	...	...
5th.									
	125	...	...	...	...	...	...	...	...
	...	...	129	...	...	...	...	...	...
	131	...	...	...	...	...	...	...	...
Fidler's Ferry	...	...	133	675	...	675	600	...	75
	137	...	...	900	...	900	1,000	100	...
Sankey Brook	...	140	...	...	...	...	...	...	...
	141	...	...	...	...	...	...	...	...
Bank Quay Reach	145	...	...	...	...	...	...	...	...
	147	...	...	350	...	350	375	25	...
	150	...	...	...	...	...	...	...	...
Lower Walton Bridge	...	152	...	300	50	250	200	...	50
	...	...	156	...	...	...	...	...	...
Welderspool	157	...	...	275	...	275	220	...	55
Warrington	...	...	160	175	...	175	190	15	...

(To be continued.)

GAUGE

FOR SCREW CUTTING TOOLS.

FIG. 6.

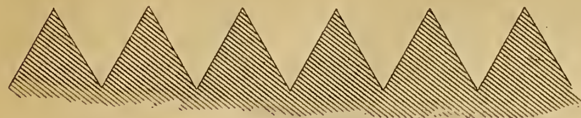


FIG. 7.

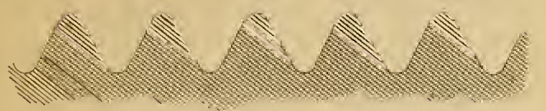


FIG. 8.

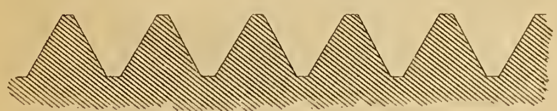


FIG 9

FIG. 3.

FIG. 2.

FIG. 1.

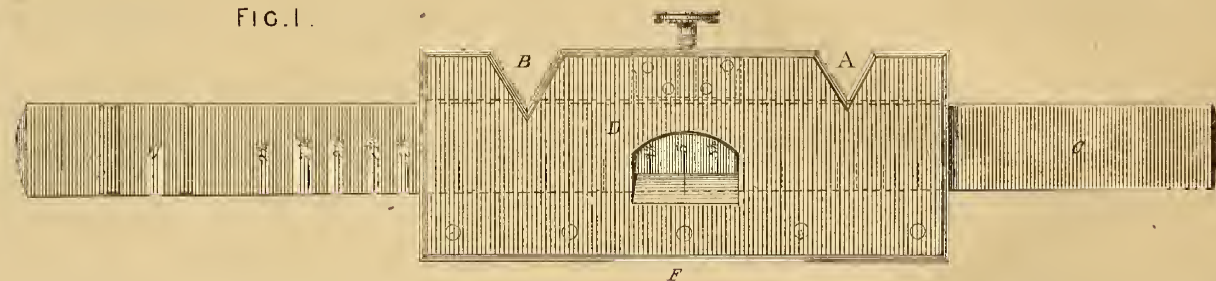


FIG. 4.

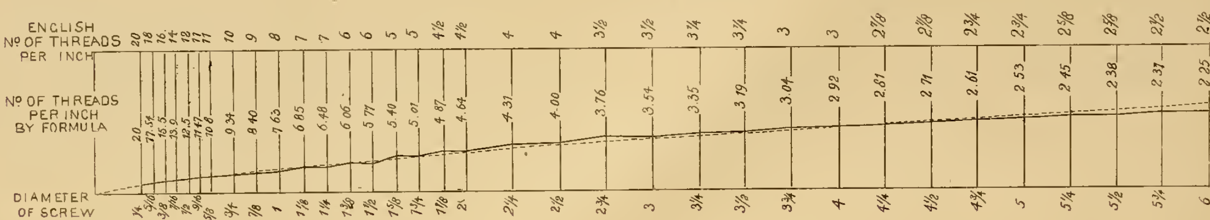
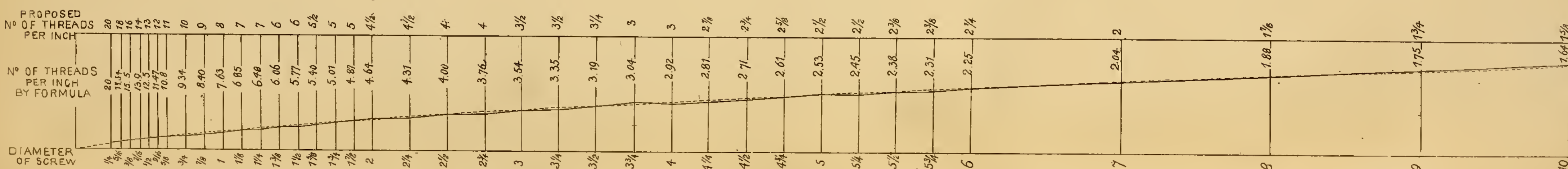


FIG. 5.



SCREW THREADS AND NUTS.

(*Illustrated by Plate* 271.)

The readers of our Exhibition Supplementary Numbers of 1862 will remember the screwing machine we therein described and illustrated—the invention of Mr. William Sellers, of Philadelphia, U.S., and President of the Franklin Institute of America.

American engineers have recently been devoting considerable attention to the subject of screw threads, bolts, and nuts, with a view to arrive at a proper system to be recommended for general adoption.

At a recent meeting of the Franklin Institute, Mr. Sellers read a paper * upon this subject, and for the insertion of which we make no apology, as it cannot fail to be of interest to engineers, &c., on this as well as the other side of the Atlantic :—

The importance of a uniform system of screw threads and nuts is so generally acknowledged by the engineering profession, that it needs no argument to set forth its advantages; and in offering any plan for their acceptance, it remains only to demonstrate its practicability and its superiority over any of the numerous special proportions now used by the different manufacturers. In this country no organised attempt has as yet been made to establish any system, each manufacturer having adopted whatever his judgment may have dictated as the best, or as most convenient for himself; but the importance of the works now in progress, and the extent to which manufacturing has attained, admonish us that so radical a defect should be allowed to exist no longer. The importance of this subject was long ago recognised in England, and the engineers of that country, by mutual agreement, adopted the proportions now in universal use there. Our standard of length being the same as theirs, it would seem desirable that the system which they have adopted should also be employed by us, unless grave objections can be urged against it and a better one substituted. In examining the details of their system, the first in importance appears to be the pitch or the distance from centre to centre of the threads upon each diameter of screw, which is as follows, viz. :—

Diameter of screw.	No. of threads per inch.	Diameter of screw.	No. of threads per inch.	Diameter of screw.	No. of threads per inch.
¼	20	1⅜	6	3½	3¼
5/16	18	1½	6	3¾	3
⅜	16	1⅝	5	4	3
7/16	14	1¾	5	4¼	2⅞
½	12	1⅞	4½	4½	2⅞
⅝	11	2	4½	4¾	2¾
¾	10	2¼	4	5	2¾
⅞	9	2½	4	5¼	2⅝
1	8	2¾	3½	5½	2⅝
1⅛	7	3	3½	5¾	2½
1¼	7	3¼	3¼	6	2½

It is probable that this scale, with the exception of the half-inch, would be a fair compromise of all the proportions used in this country. The diagram, fig. 4, in the accompanying plate will serve to show the comparative relation which these pitches bear to each other and to their diameter. This indicates also that the pitch of the half-inch screw is too coarse; our practice would probably average finer. It is interesting to observe the general regularity of the curve produced by these proportions, showing that, notwithstanding they have been determined arbitrarily, they must follow some rule; and we accordingly find that the number of threads per inch may be expressed to the nearest aliquot of an inch by the formula $1 \div \frac{\sqrt{d} - a}{c}$, in which d variable = number of sixteenths of an inch in the diameter of the screw, + ten, a = constant 2·909, and c = divisor 16·64. The table herewith, calculated to this formula, shows that the English screws, with the exception of six sizes, do not vary from the rule until they reach 4½in. diameter, and then but slightly. It is believed the pitches as given by the formula would be found an improvement, but not sufficiently so to warrant us in adopting them, providing the other peculiarities of the English system should meet our approval.

Diameter of screw.	Formula thread.	Nearest aliquot.	English thread.	Diameter of screw.	Formula thread.	Nearest aliquot.	English thread.	Diameter of screw.	Formula thread.	Nearest aliquot.	English thread.
¼	20	20	20	1⅜	6·06	6	6	3½	3·19	3¼	3¼
5/16	17·54	18	18	1½	5·77	6	6	3¾	3·04	3	3
⅜	15·5	16	16	1⅝	5·40	5½	5	4	2·92	3	3
7/16	13·9	14	14	1¾	5·11	5	5	4¼	2·81	2⅞	2⅞
½	12·5	13	12	1⅞	4·87	5	4½	4½	2·71	2¾	2⅞
⅝	10·8	11	11	2	4·64	4½	4½	4¾	2·61	2⅝	2¾
¾	9·34	10	10	2¼	4·31	4½	4	5	2·53	2½	2¾
⅞	8·40	9	9	2½	4·00	4	4	5¼	2·45	2½	2⅝
1	7·63	8	8	2¾	3·76	4	3½	5½	2·38	2⅜	2⅝
1⅛	6·98	7	7	3	3·54	3½	3½	5¾	2·31	2⅜	2½
1¼	6·48	7	7	3¼	3·35	3½	3¼	6	2·25	2¼	2½

The form of thread adopted by the English engineers is one with flat sides at an angle to each other of 55°, with a rounded top and bottom. The proportions for the rounded top and bottom are obtained by dividing the depth of a sharp thread, having sides at an angle of 55°, into six equal parts, and within the lines formed by the sides of the thread and the top and bottom dividing lines, inscribing a circle which determines the form of top and bottom of thread, as illustrated by Fig. 7, Plate 271. Judging from the practice of this country, the English form of thread has not met with the same favour that has been accorded to their pitches. Its advantages over the sharp thread are increased strength to the screw from the absence of acute corners, and the greater security from accidental injury which the rounded top possesses. Its objectionable features are, first, that the angle of 55° is a difficult one to verify; it is probable, no gauges to this angle, made independently of each other, and without special tools, would correspond with sufficient accuracy. Secondly, the curve at the top and bottom of the thread of the screw will not fit the corresponding curve in the nut, and the wearing surface on the thread will be thus reduced to the straight sides merely. It is not to be inferred from this that these curves cannot be made to fit, but only that the difficulties in producing contact are so much increased by the peculiar form, that in practice it will not be accomplished. Thirdly, the increased cost and complication of cutting tools required to form this kind of thread in a lathe, it being requisite that this tool shall have at least three cutting sides, in order to form the round top between two of them. The English practice for small work, is to rough out in a slide lathe with a single-point tool having sides of the proper angle, and finish in a hand lathe with a comb chaser, which has been dressed to the proper form upon a hob kept for that purpose, requiring three kinds of cutters and two lathes to per-

* Published in the Proceedings of the Institute.

form what with our practice requires but one cutter and one lathe. On large work, the screw is finished in the slide lathe, with a chasing tool dressed to the proper form upon a hob; and as these hobs are necessarily the standards of form until worn out, it is fair to suppose the shape must be undergoing a continual change. The necessity of guarding the edge of the thread from accidental injury becomes more and more apparent as the size of the bolt is increased, and we have recognised this by finishing such bolts with a small flat upon the top of the thread; but no plan has been proposed for general adoption upon all screws, nor have any proportions been suggested where a flat is desired, or where from the size of the bolt it would seem to be necessary. As it is very desirable that some uniform rule should be observed in the formation of all threads, and as the sharp top is objectionable upon large screws, this form must be abandoned if we would accomplish our object. It being conceded that the flat angular sides are necessary, we have only to choose between the rounded and flat top; and having examined the former, it only remains to notice whether the flat will be found free from the objections urged against the round. As the sides of the thread are the only parts requiring to be fitted, and as these are of the same shape as the sharp thread, the one will be as easily made as the other. The width of the flat top will be determined by the depth to which the thread is cut, so that the same tool can be used in both cases. The flat on the top of the thread being required to protect it from injury, it is evident a similar shape at the bottom would give increased strength to the bolt as well as improve its appearance. To give this form requires only that the point of the cutting tool shall be taken off, and then it is evident this thread can be cut in a lathe with the same tool and in the same manner as the sharp thread. The width of flat in the bottom of thread being dependent upon the amount taken off the point of the tool, it becomes necessary not only to determine what this amount shall be, but also to provide a means of measuring it. The proportions for the proposed thread and its comparative relation to the sharp and rounded threads, will be readily understood from the diagrams in the accompanying Plate 271, in which Fig. 6 represents a sharp thread, Fig. 7 a rounded top and bottom to the English proportions, and Fig. 8 the flat top and bottom, all of the same pitch. The angle of the proposed thread is fixed at 60°, the same as the sharp thread, it being more readily obtained than 55°, and more in accordance with the general practice in this country. Divide the pitch, or, which is the same thing, the side of the thread, into eight equal parts, take off one part from the top and fill in one part in the bottom of the thread, then the flat top and bottom will equal one-eighth of the pitch, the wearing surface will be three-quarters of the pitch, and the diameter of screw at bottom of the thread will be expressed by the formula diam. $- \frac{1·299}{\text{per in.}}$. These proportions will give the depth of the thread almost precisely the same as the English, and as the wearing surface on all screws will be confined practically to the flat sides, we shall find that upon the proposed plan this will be 36 per cent. greater than on the English. The gauge shown in Fig. 1, Plate 271, is designed for measuring the flat upon the chasing tool. D is the main frame of the instrument made in three thicknesses, so that the central pieces may be hardened and ground to shape, the outer pieces serving to keep the central ones in their proper positions. A is an angle of 60° cut in the edge of the frame D, and having its two sides to form equal angles with the edge of the frame. B is similar to A, but having the apex of the angle cut away so as to permit the wedge piece C to pass above the point of junction of the two sides of B. The side of C is graduated, so that upon bringing any particular mark to coincide with a fixed point or mark in the frame D, the edge of C will pass the proper distance above the apex of the angle B, which will indicate the amount to be taken off the point of the chasing tool which has first been accurately fitted to the angle A. In setting the chasing tool in the lathe, the side F of the gauge should be placed against the surface of the work to be cut, which is suspended upon the centres, and while in this position the chasing tool must be adjusted to it and securely fastened. This will insure the thread when cut being perpendicular to the surface. The width of the flat top and bottom may also be obtained by the use of a chasing tool having a flat on its end of known width, but less than required in the bottom of the thread; the depth of the thread having been determined, the tool may cut in to this point and finish by a side movement sufficient to give the required amount of flat.

A system of uniform dimensions for bolt heads and nuts being intimately connected with the subject just discussed, it is believed that a convenient formula that would express the required size would go far towards inducing a uniform practice, and with this view the following formulæ and tables for screw threads and nuts are offered for the acceptance of our engineers. Should they meet the approval and be adopted by a considerable portion of the profession, there is every reason to believe they would soon be applied universally; and to enable a comparison to be readily instituted between the systems which have been discussed, diagrams Figs. 5 and 9, Plate 271, have been prepared, the former representing the pitch as obtained by the formula, with that proposed to be adopted, and the latter representing a section of a ten inch bolt, having its threads to the same proportion. To compare the form of thread, two of $\frac{7}{8}$ and 2 inch taps exhibited are by Whitworth and Co., to the English standard, and the other two of same size are to the proposed threads. Formulæ:—

Δ = diameter of screws.
d = No. of sixteenths plus ten in Δ.
x = pitch of screws.
v = No. of threads per in.
a = constant 2·909.
c = divisor 16·64.
m = flat top and bottom.
n = diameter of screws at bottom.
s = short diam. of nut or bolt head = $1\frac{1}{2}$ diameter of screws + $\frac{1}{8}$in.
u = long diam. hexagonal nut or bolt head.
t = long diam. square nut or bolt head.

$$x = \frac{\sqrt{d} - a}{c} \qquad v = \frac{1}{x} \qquad t = s \times 1·414$$

$$m = \frac{x}{8} \qquad n = \Delta - \frac{1·299}{v}$$

$$s = \frac{3\,\Delta}{2} + \tfrac{1}{8}\text{in.} \qquad u = s \times 1·155$$

Proportions of Bolts.				Proportions of Nuts.			
Diameter of bolt.	Number of threads per inch.	Diameter of root of thread.	Width of flat top, bottom of thread.	Size hole in nut.	Short diameter of hex-nut.	Long diameter of hex-nut.	Long diameter of sq. nut.
							
$\frac{1}{4}$	20	·185	·0062	·185	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{11}{16}$
$\frac{5}{16}$	18	·240	·0070	·240	$\frac{19}{32}$	$\frac{11}{36}$	$\frac{13}{16}$
$\frac{3}{8}$	16	·294	·0078	·294	$\frac{11}{16}$	$\frac{25}{32}$	$\frac{31}{32}$
$\frac{7}{16}$	14	·344	·0089	·344	$\frac{25}{32}$	$\frac{43}{48}$	$1\frac{1}{16}$
$\frac{1}{2}$	13	·400	·0096	·400	$\frac{7}{8}$	1	$1\frac{1}{4}$
$\frac{9}{16}$	12	·454	·0104	·450	$\frac{31}{32}$	$1\frac{7}{64}$	$1\frac{5}{16}$
$\frac{5}{8}$	11	·507	·0113	·507	$1\frac{1}{16}$	$1\frac{7}{32}$	$1\frac{1}{2}$
$\frac{3}{4}$	10	·620	·0125	·620	$1\frac{1}{4}$	$1\frac{7}{16}$	$1\frac{3}{4}$
$\frac{7}{8}$	9	·731	·0140	·731	$1\frac{7}{16}$	$1\frac{21}{32}$	$2\frac{1}{32}$
1	8	·837	·0156	·837	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{5}{16}$
$1\frac{1}{8}$	7	·940	·0180	·940	$1\frac{13}{16}$	$2\frac{3}{32}$	$2\frac{1}{2}$
$1\frac{1}{4}$	7	1·065	·0180	1·065	2	$2\frac{5}{16}$	$2\frac{27}{32}$
$1\frac{3}{8}$	6	1·160	·0210	1·160	$2\frac{3}{16}$	$2\frac{1}{2}$	$3\frac{1}{10}$
$1\frac{1}{2}$	6	1·284	·0210	1·284	$2\frac{3}{8}$	$2\frac{3}{4}$	$3\frac{3}{8}$
$1\frac{5}{8}$	$5\frac{1}{2}$	1·389	·0227	1·389	$2\frac{9}{16}$	$2\frac{15}{16}$	$3\frac{5}{8}$
$1\frac{3}{4}$	5	1·490	·0250	1·490	$2\frac{3}{4}$	$3\frac{3}{16}$	$3\frac{29}{32}$
$1\frac{7}{8}$	5	1·615	·0250	1·615	$2\frac{15}{16}$	$3\frac{13}{32}$	$4\frac{3}{16}$
2	$4\frac{1}{2}$	1·712	·0280	1·712	$3\frac{1}{8}$	$3\frac{5}{8}$	$4\frac{7}{16}$
$2\frac{1}{4}$	$4\frac{1}{2}$	1·962	·0280	1·962	$3\frac{1}{2}$	$4\frac{1}{16}$	$4\frac{31}{32}$
$2\frac{1}{2}$	4	2·175	·0310	2·175	$3\frac{7}{8}$	$4\frac{1}{2}$	$5\frac{1}{2}$
$2\frac{3}{4}$	4	2·425	·0310	2·425	$4\frac{1}{4}$	$4\frac{29}{32}$	6
3	$3\frac{1}{2}$	2·628	·0357	2·628	$4\frac{5}{8}$	$5\frac{3}{8}$	$6\frac{9}{16}$
$3\frac{1}{4}$	$3\frac{1}{2}$	2·878	·0357	2·878	5	$5\frac{3}{4}$	$7\frac{1}{8}$
$3\frac{1}{2}$	$3\frac{1}{4}$	3·100	·0384	3·100	$5\frac{3}{8}$	$6\frac{7}{64}$	$7\frac{5}{8}$
$3\frac{3}{4}$	3	3·317	·0410	3·317	$5\frac{3}{4}$	$6\frac{5}{8}$	$8\frac{3}{16}$
4	3	3·566	·0410	3·566	$6\frac{1}{8}$	$7\frac{31}{64}$	$8\frac{11}{16}$
$4\frac{1}{4}$	$2\frac{7}{8}$	3·798	·0435	3·825	$6\frac{1}{2}$	$7\frac{1}{2}$	$9\frac{1}{4}$
$4\frac{1}{2}$	$2\frac{3}{4}$	4·027	·0460	4·027	$6\frac{7}{8}$	$7\frac{31}{32}$	$9\frac{3}{4}$
$4\frac{3}{4}$	$2\frac{5}{8}$	4·255	·0480	4·255	$7\frac{1}{4}$	$8\frac{3}{8}$	$10\frac{9}{32}$
5	$2\frac{1}{2}$	4·480	·0500	4·480	$7\frac{5}{8}$	$8\frac{13}{16}$	$10\frac{13}{16}$
$5\frac{1}{4}$	$2\frac{1}{2}$	4·730	·0500	4·730	8	$9\frac{1}{4}$	$11\frac{3}{8}$
$5\frac{1}{2}$	$2\frac{3}{8}$	4·953	·0526	5·053	$8\frac{3}{8}$	$9\frac{11}{16}$	$11\frac{29}{32}$
$5\frac{3}{4}$	$2\frac{3}{8}$	5·203	·0526	5·203	$8\frac{3}{4}$	$10\frac{1}{8}$	$12\frac{7}{16}$
6	$2\frac{1}{4}$	5·423	·0555	5·423	$9\frac{1}{8}$	$10\frac{9}{16}$	$12\frac{9}{10}$

ECONOMY IN THE USE OF STEAM.

By D. M. GREENE, C.E., Second Assist. Eng. U.S.N.

(From the Journal of the Franklin Institute.)

(*Concluded from page* 254.)

The diagram, Fig. 3, exhibits the law which governs the cost of net power, as determined by our formula (13)—and shows how nearly the results of theory, as we have applied it, agree with those of careful experiment. The ordinates of the curves represent the cost of a horse-power at the corresponding points, of cutting off; the upper curve is constructed in accordance with the results given by (13), under the conditions of the "Erie Experiments;" the lower curve with the results for $p = 9$ atmospheres = 132·3 pounds; and the middle curve with the results of the "Erie Experiments."* In the last case, the numbers represented by the ordinates which determine the curvature, are taken from line 29, Table 1, facing page 100, in Chief Engineer Isherwood's "Experimental Researches in Steam Engineering;" the points of cutting off, in these "Experiments," were $\frac{11}{12}$, $\frac{7}{10}$, $\frac{4}{9}$, $\frac{3}{10}$, $\frac{1}{4}$, ^{1}, and $\frac{4}{45}$; and the corresponding costs, in pounds of steam per net horse-power, per hour, 42·971, 37·662, 36·135, 39·357 39·202, 43·803, and 60·53 respectively.

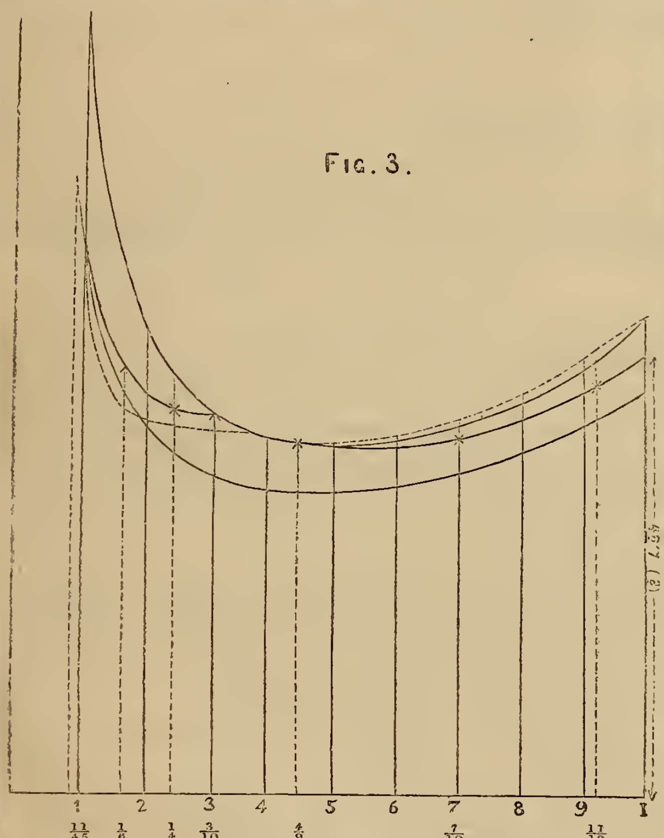


FIG. 3.

Vertical Scale, 1″ = 20 pounds.

It will be observed that, as regards the measure of expansion which insures the greatest economy, the results obtained by the use of our formula fully confirm the correctness of the conclusions of Chief Engineer Isherwood; it will also be observed that for points between $\frac{3}{10}$ and $\frac{7}{10}$ of the stroke, our theoretical results are nearly identical with the experimental results; and hence, since nearly all the points of cut-off employed in practice are embraced within the limits specified, it seems that we are justified in making the assumption that the formula will, in all practical cases, give results which may be relied upon as being practically correct. Again, since the point of cutting off which insures the maximum economy is the same for steam of 2·43 and 9 atmospheres, it may be assumed that it will be the same for all presures between those limits.

It should be remarked also, that where the experimental results differ from those given by the formula, the experimental cost is *less* than the theoretical; hence if provision be made for the evaporation of the theoretical quantity of water for a given power, the development of the required power will always be realized.

Under the conditions upon which the "Erie Experiments" were made the formula indicates that the maximum gain, in net power, that can be realized from expansion is $\frac{51·16 - 36·5}{56·16} \times 100 = 26·11$ per cent. of that developed when the steam is used without expansion.

According to the experimental results, the maximum gain due to expansion was probably (see Fig. 4)

$$\frac{46·7 - 36·235}{46·7} \times 10 = 22·41 \text{ per cent.}$$

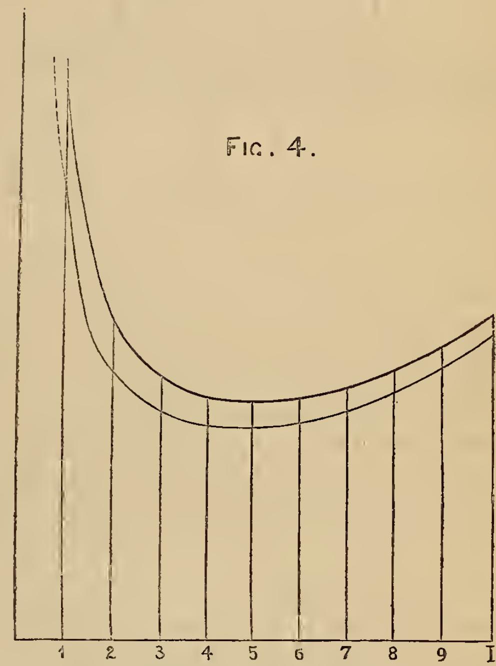


FIG. 4.

Vertical Scale, 1″ = 30 pounds.

If we take ordinates of the dotted curve—of fuel—we shall obtain for the maximum saving in fuel, a result identical with that first found, from the results given by the formula (13). This is evident from the fact that the ordinates of the two curves, at full stroke, and at the point of minimum cost, are identical.

For the purpose of exhibiting the effect of clearance upon the measure of expansion due to the maximum economy, the following table—containing the costs for different values of c,—other things being the same as in the "Erie Experiments"—has been constructed: the numbers in the Table being obtained by substituting different values of c, in (13).

Cut-off.	Cost of a Horse-power.			
	$p = 35·7$ (1) C = 2 per cent.	$p = 35·7$ (2) C = 5·8 per cent.	$p = 35·7$ (3) C = 8 per cent.	$\frac{(3)-(1)}{(3)} \times 100$
$\frac{1}{10}$	70·58	81·21	89·37	21·25
$\frac{2}{10}$	42·37	47·35	50·15	15·51
$\frac{3}{10}$	36·27	39·53	41·43	12·45
$\frac{4}{10}$	34·33	36·96	38·44	10·69
$\frac{5}{10}$	34·34	36·50	37·85	9·27
$\frac{6}{10}$	35·12	37·26	38·26	8·21
$\frac{7}{10}$	36·93	38·89	39·97	7·61
$\frac{8}{10}$	39·92	41·85	42·83	6·79
$\frac{9}{10}$	42·49	44·63	45·59	6·78
$\frac{10}{10}$	49·33	51·16	52·21	5·52

The results in columns (1) and (3) of the Table, are represented

* The dotted curve has been added, representing the expenditure of *fuel* in the "Erie Experiments;" *i.e.*, its ordinates represent the cost of a horse-power, when the steam was cut off at the points at which they are erected.

graphically in the diagram, Fig. 4, which shows that by diminishing the clearance space, the absolute cost of the power is materially reduced; while the measure of expansion which insures the best results, becomes sligbtly greater than when the clearance is larger; or, which is tbe same tbing, tbe best point of cutting off is slightly nearer the beginning of the stroke, when the clearance is small.

If, in any case—having calculated the costs of a horse-power for different points of cutting off—it be desired to determine the costs for a different pressure, other things remaining the same, the labour may be considerably reduced by tabulating the values of the factor

$$\left[\frac{a}{a+c} + \text{hyp. log. } \frac{l+c}{a+c}\right]$$

in (13); which, it will be observed, is constant for all pressures.

The following Table contains the different value of this factor, for clearances, from 1 to 8 per cent. of the cylinder :—

Cut-off.	C = 1 per cent.	C = 2 per cent.	C = 3 per cent.	C = 4 per cent.	C = 5 per cent.	C = 6 per cent.	C = 7 per cent.	C = 8 per cent.	C = 5·8 per cent.
$\frac{1}{10}$	3·126	2·973	2·839	2·719	2·613	2·516	2·429	2·348	2·584
$\frac{2}{10}$	2·523	2·443	2·372	2·300	2·235	2·163	2·118	2·064	2·186
$\frac{3}{10}$	2·159	2·096	2·012	1·983	1·956	1·913	1·873	1·835	1·923
$\frac{4}{10}$	1·877	1·841	1·805	1·769	1·736	1·704	1·673	1·644	1·710
$\frac{5}{10}$	1·663	1·635	1·608	1·582	1·556	1·535	1·507	1·483	1·538
$\frac{6}{10}$	1·487	1·465	1·443	1·423	1·402	1·380	1·366	1·345	1·381
$\frac{7}{10}$	1·339	1·326	1·302	1·286	1·269	1·257	1·245	1·225	1·259
$\frac{8}{10}$	1·209	1·194	1·178	1·166	1·152	1·139	1·127	1·113	1·139
$\frac{9}{10}$	1·093	1·089	1·071	1·060	1·047	1·036	1·025	1·015	1·037
$\frac{10}{10}$	0·990	0·980	0·971	0·961	0·952	0·943	0·934	0·926	0·945

In conclusion it should be stated, that owing to the time and labour required, the numbers in the several tables that have been constructed in connexion with the discussion of this subject, have not been systematically verified; but in view of the great care which has been exercised in making the computations, to avoid errors, the writer does not hesitate to express the confident opinion, that whatever trifling errors may have crept in, have not sensibly affected the results; indeed, the uniform regularity of the curves constructed with the results—so far as curves have been constructed—is evidence of itself that appreciable errors have been avoided: however tbis may be, there seems to be no reasonable ground for doubt in regard to the conclusiveness of the proof of the correctness of Mr. Isherwood's "peculiar" theory—at least, so far as *economy* is concerned.

Naval Academy, Newport, R.I.

PROFESSOR ZEUNER'S TABLE OF THE PROPERTIES OF SATURATED STEAM.

(*Continued from page* 125.)

We gave in our issue of June 1 of this year Herr Zeuner's Table, with the deductions from which the results contained therein were arrived at. We now give, by way of example, the problem worked out by Professor Zeuner himself, in order to illustrate the application of the table.

Tbe question to be solved is the following :—*In what manner will the pressure of steam increase in a boiler which is continued to be heated after the egress of steam has been stopped, and the valve shut off, from a certain moment.*

Supposing the weight of water and steam combined in the boiler to be M kilos., m kilos. of which being steam, at the moment the valve is shut off, t = tbe temperature, p the pressure, and all other letters to denote the same as before (see page 122), tbe volume of water contained within the boiler will then be = $(M - m)\, w$, the volume of steam = $m\, v$; therefore the volume of water and steam combined

$$V = (M - m)\, w + m\, v = M\, w + m\, (v - w);$$

or, by equation (3),

$$V = M\, w + m\, v.$$

Supposing the quantity of steam in the boiler to increase by the heating process, and m to assume the value m_1, t the value t_1, and p the value of p_1, after the lapse of τ minutes; the value of u will become u_1, as there is no change in the volume, and we shall have

$$V = M\, w + m_1\, u_1$$

$$m_1\, u_1 = m\, u.$$

The quantity of steam, m, can, therefore, easily be calculated for every temperature t_1.

Tbe quantity of heat tbat was contained in the water at the beginning was = $(M - m)\, q$, that contained in the steam was = m J; therefore the quantity of heat contained in the volume of water and steam combined will be

$$(M - m)\, q + m\, J = M\, q + m\, (J - q)$$

$$J - q = \rho \text{ (by equation (9))}$$

$$\therefore M\, q + m\, (J - q) = M\, q + m\, \rho.$$

For a temperature, t_1, we shall have

$$M\, q_1 + m_1\, \rho_1;$$

and, consequently, the quantity of heat to be supplied, in order to raise the temperature from t to t_1, will be

$$Q = M\, (q_1 - q) + m_1\, \rho_1 - m\, \rho.$$

By substituting for the values of q, q_1, and m_1, those given by equations (10) to (12), we shall have

$$Q = M\, c\, (t_1 - t) + m\, u \left(\frac{\rho_1}{u_1} - \frac{\rho}{u}\right).$$

Supposing, now, Q_0 to denote the quantity of heat that passes through the boiler in every unit of time, we shall have for τ minutes during which the temperature rises from t to t_1, and the pressure from p to p_1:—

$$\tau = \frac{Q}{Q_0} = \frac{1}{Q_0}\left[M\, c\, (t_1 - t) + m\, u \left(\frac{\rho_1}{u_1} - \frac{\rho}{u}\right)\right] \text{.......... (13)}$$

By this equation the problem is completely solved. It is obvious that the coefficient M c $(t_1 - t)$ will represent a much larger number than $m\, u \left(\frac{\rho_1}{u_1} - \frac{\rho}{u}\right)$, the weight of the water in the boiler being always by far larger than tbe weight of steam therein. The increase of the temperature, $t_1 - t$, will therefore be proportionate to the time, τ, as has been confirmed by the investigations of Mr. Fairbairn, and lately by Professor von Burg, of Vienna, in his paper "On the Efficacy of Safety Valves."* The formulæ given heretofore also coincide with tbe results of Mr. Fairbairn's experiments.

We shall illustrate the above by a numerical example. Supposing a steam boiler to have a heating surface of 18 square metres (194 square feet), and a capacity of 11 cubic metres (388·5 cubic feet), these dimensions will correspond to those of a boiler for an engine of about 15 H.P. Tbis boiler will yield 7·5 kilos. (16·51b. avoirdupois) of steam per minute, by the usual heating process. Supposing the average pressure of the steam to be four atmospheres (58·7881b. per square inch), the temperature of water and steam will be = 144° C. = 291·20° F.

In order to generate steam at a constant pressure, we must supply to each kilogramme of feed water of 0° C. introduced in the boiler a quantity of heat

$$J + A\, p\, u = 607{\cdot}06 + 43{\cdot}49 = 650{\cdot}55 \text{ units of heat.}$$

At the moment the temperature of water reaches 15° C., the quantity of heat to be supplied will be

$$650{\cdot}55 - 15 = 635{\cdot}55 \text{ units (calories).}$$

The boiler yielding 7·5 kilos. of steam pr. 1″, the quantity of heat to be supplied to the boiler, pr. 1″, will be

$$Q_0 = 7{\cdot}5 \times 635{\cdot}55 = 4766{\cdot}62 \text{ calories.}$$

Supposing, now, the egress of the steam to be stopped, while the same quantity of heat, Q_0, continues to be supplied to the boiler by means of the heating process, the question arises in what time the pressure of four atmospheres will have increased to eight atmospheres, provided six-tenths of the capacity of the boiler be filled with water, and four-tentbs with steam of four atmospheres, at tbe moment the egress of steam is interrupted.

The capacity of the boiler being V = 11 cubic metres, the weight of the water it contains will be

$$0{\cdot}6 \times 11 \times 1000 = 6600 \text{ kilos.}$$

* See "Sitzungsberichte der Wiener Akademie," vol. xlv. p. 313.

By the table, the weight of a cubic metre of steam at four atmosphere pressure is = 2·237 kilos.; therefore

$$m = 0·4 \times 11 \times 2·237 = 9·84 \text{ kilos.}$$

The aggregate weight of water and steam combined will be, therefore,

$$M = 6600 + 9·84 = 6609·84 \text{ kilos.}$$

The coefficients of formula (13) will be, for the original pressure of four atmospheres,

$$t = 144°; \; u = 0·4461; \; \frac{\rho}{u} = 1031·63;$$

and for a pressure of eight atmospheres

$$t_1 = 170·81; \; \frac{\rho_1}{u_1} = 1891·96.$$

Substituting these values, we have

$$M\,c\,(t_1 - t) = 181{,}179·2$$

$$m\,u\left(\frac{\rho_1}{u_1} - \frac{\rho}{u}\right) = 3763·3;$$

and as $Q_0 = 4766·62$, we find

$$\tau = \frac{181{,}179·2 + 3763·3}{4766·62} = 38·80 \text{ minutes.}$$

i.e., in a boiler worked under the above conditions, the pressure of steam will require 38·8 minutes to rise from four to eight atmospheres.

Supposing, on the other hand, the volume of water in the boiler to be less than that of the steam, at the moment the egress of the latter is stopped, say, *e. g.*, the proportion to be water : steam :: 0·4 : 0·6, the weight of the steam would be

$$m = 14·76 \text{ kilos.,}$$

and water and steam combined

$$M = 4414·76 \text{ kilos.}$$

and to raise the pressure from four to eight atmospheres, we should, then, require a lapse of time

$$\tau = 26·57 \text{ minutes,}$$

i. e., 12·23 minutes less than in the former instance.

The following table exhibits the values of the several coefficients for the same boiler, for pressures varying from four to twelve atmospheres.

Pressure in Atmospheres.	Temperature in Degrees Centigrade.	Differences, $t_1 - t$.	Volume of Water in the Boiler. 0·6 V. Lapse of Time τ''.	0·6 V. Differences.	0·4 V. Lapse of Time τ''.	0·4 V. Differences.
Original 4	t = 144·00	...	...	...	...	...
5	t_1 = 152·22	8·22	11·86	11·86	8·09	8·09
6	159·22	15·32	21·97	10·11	15·01	6·92
7	165·34	21·34	30·85	9·88	21·11	6·10
8	170·81	26·81	38·80	7·95	26·57	5·46
9	175·77	31·77	46·02	7·22	31·55	4·98
10	180·31	36·31	52·64	6·62	36·12	4·57
11	184·50	40·50	58·76	6·12	40·36	4·24
12	188·41	44·41	64·48	5·72	44·32	3·96

This table shows that the inference drawn by Councillor von Burg from Mr. Fairbairn's experiments, viz., that the temperature in the boiler increases in proportion to the time, is perfectly justified. The speed with which the pressure in a closed boiler increased will depend on the quantity of water in the same: the less water there is, the more the pressure will increase, and with it the liability to explode. All this corroborated Bernouilli's opinion, that the quantity of water in the boiler is the real standard of the pressure of the steam.

ERRATA.—In the table published in our June number, p. 124, column 7, line 33 from the bottom, for "240·97," read "239·97;" line 32 from the bottom, for "244·14," read "243·14;" in p. 125, column 7, line 5 from the top, for "210·25" read "211·25."

THE ROYAL SOCIETY.

FURTHER INQUIRIES CONCERNING THE LAWS AND OPERATION OF ELECTRICAL FORCE.

By SIR W. SNOW HARRIS, F.R.S., &c.

(Abstract.)

1. The author first endeavours to definitely express what is meant by *quantity of electricity, electrical charge*, and *intensity*.

By *quantity of electricity* he understands the actual amount of the unknown agency constituting electrical force, as represented by some arbitrary quantitative "electrical" measure. By *electrical charge* he understands the quantity which can be sustained upon a given surface under a given electrometer indication. *Electrical intensity*, on the contrary, is "the electrometer indication" answering to a given quantity upon a given surface.

2. The experiments of Le Monnier in 1746, of Cavendish in 1770, and the papers of Volta in 1779, are quoted as showing that bodies do not take up electricity in proportion to their surfaces. According to Volta, any plane surface extended in length sustains a greater charge,—a result which this distinguished philosopher attributes to the circumstance that the electrical particles are further apart upon the elongated surface, and consequently further without each other's influence.

3. The author here endeavours to show that, in extending a surface in length, we expose it to a larger amount of inductive action from surrounding matter, by which, on the principles of the condenser, the intensity of the accumulation is diminished, and the charge consequently increased; so that not only are we to take into account the influence of the particles on each other, but likewise their operation upon surrounding matter.

4. No very satisfactory experiments seem to have been instituted showing the relation of quantity to surface. The quantity upon a given surface has been often vaguely estimated without any regard to a constant electrometer indication or intensity. The author thinks we can scarcely infer from the beautiful experiment of Coulomb, in consequence of this omission, that the capacity of a circular plate of twice the diameter of a given sphere is twice the capacity of the sphere, and endeavours to show, in a future part of the paper (Experiment 16), that the charge of the sphere and plate are to each other not really as 1·2, but as $1 : \sqrt{2}$, that is, as the square roots of exposed surfaces: so that we cannot accumulate twice the quantity of electricity upon the plate under the same electrometer indication.

5. On a further investigation of the laws of electrical charge, the quantity which any plane rectangular surface can receive under a given intensity is found to depend not only on the surface, but also on its linear boundary extension. Thus the linear boundary of 100 square inches of surface under a rectangle 37·5 inches long by 2·66 inches wide, is about 80 inches; whilst the linear boundary of the same 100 square inches of surface under a plate of 10 inches square is only 40 inches. Hence the charge of the rectangle is much greater than that of the square, although the surfaces are equal, or nearly so.

6. The author finds, by a rigid experimental examination of this question, that electrical charge depends upon surface and linear extension conjointly. He endeavours to show that there exists in every plane surface what may be termed an electrical boundary, having an important relation to the grouping or disposition of the electrical particles in regard to each other and to surrounding matter. This boundary, in circles or globes, is represented by their circumferences. In plane rectangular surfaces, it is their linear extension or perimeter. If this *boundary* be constant, their electrical charge (1) varies with the square root of the surface. If the *surface* be constant, the charge varies with the square root of the boundary. If the surface and boundary both vary, the charge varies with the square root of the surface multiplied into the square root of the boundary. Thus, calling C the charge, S the surface, B the boundary, and μ some arbitrary constant depending on the electrical unit of charge, we have $C = \mu\sqrt{S.B}$, which will be found, with some exceptions, a general law of electrical charge. It follows from this formula, that if when we double the surface we also double the boundary, the charge will be also double. In this case the charge may be said to vary with the surface, since it varies with the square root of the surface, multiplied into the square root of the boundary. If, therefore, the surface and boundary both increase together, the charge will vary with the square of either quantity. The quantity of electricity, therefore, which surfaces can sustain under these conditions, will be as the surface. If l and b represent respectively the length and breadth of a plane rectangular surface, then the charge of such a surface is expressed by $\mu\sqrt{2\,l\,b\,(l+b)}$, which is found to agree perfectly with experiment. We have, however, in all these cases to bear in mind the difference between *electrical charge* and *electrical intensity* (1).

7. The electrical intensity of plane rectangular surfaces is found to vary in an inverse ratio of the boundary multiplied into the surface. If the surface be constant, the intensity is inversely as the boundary. If the boundary be constant, the intensity is inversely as the surface. If both vary alike and together, the intensity is as the square of either quantity; so that if when the surface be doubled the boundary be also doubled, the intensity will be inversely as the square of the surface. The intensity of a plane rectangular surface being given, we may always deduce therefrom its electrical charge under a given greater intensity, since we only require to determine the increased quantity requisite to bring the electrometer indication up to the given required intensity. This is readily deduced, the intensity being, by a well-established law of electrical force, as the square of the quantity.

8. These laws relating to charge, surface, intensity, &c., apply more especially to continuous surfaces taken as a whole, and not to surfaces divided into separated parts. The author illustrates this by examining the result of an electrical accumulation upon a plane rectangular surface taken as a whole, and the results of the same accumulation upon the same surface divided into two equal

and similar portions distant from each other, and endeavours to show, that if as we increase the quantity we also increase the surface and boundary, the intensity does not change. If three or more separated equal spheres, for example, be charged with three or more equal quantities, and be placed each in separate connexion with the electrometer, the intensity of the whole is not greater than the intensity of one of the parts. A similar result ensues in charging any united number of equal and similar electrical jars. A battery of five equal and similar jars, for example, charged with a given quantity = 1, has the same intensity as a battery of ten equal and similar jars charged with quantity = 2; so that the intensity of the ten jars taken together is no greater than the intensity of one of the jars taken singly. In accumulating a double quantity upon a given surface divided into two equal and separate parts, the boundaries of each being the same, the intensity varies inversely at the square of the surface. Hence two separate equal parts can receive, taken together under the same electrometer indication, twice the quantity which either can receive alone, in which case the charge varies with the surface. Thus if a given quantity be disposed upon two equal and similar jars instead of upon one of the jars only, the intensity upon the two jars will be only one-fourth the intensity of one of them, since the intensity in this case varies with the square of the surface inversely, while the quantity upon the two jars under the same electrometer indication will be double the quantity upon one of them only; in which case the charge varies with the surface, the intensity being constant. If, therefore, as we increase the number of equal and similar jars we also increase the quantity, the intensity remains the same, and the charge will increase with the number of jars. Taking a given surface, therefore, in equal and divided parts, as for example four equal and similar electrical jars, the intensity is found to vary with the square of the quantity directly (the number of jars remaining the same), and with the square of the surface inversely (the number of jars being increased or diminished); hence the charge will vary as the square of the quantity divided by the square of the surface; and we have, calling C the charge, Q the quantity, and S the surface, $C = \frac{Q^2}{S^2}$; which formula fully represents the phenomenon of a constant intensity, attendant upon the charging of equal separated surfaces with quantities increasing as the surfaces; as in the case of charging an increasing number of equal electrical jars. Cases, however, may possibly arise in which the intensity varies inversely with the surface, and not inversely with the square of the surface. In such cases, of which the author gives some examples, the above formula does not apply.

9. From these inquiries it is evident, as observed by the early electricians, that conducting bodies do not take up electricity in proportion to their surfaces, except under certain relations of surface and boundary. If a breadth of a given surface be indefinitely diminished, and the length indefinitely increased, the surface remaining constant, then, as observed by Volta, the least quantity which can be accumulated under a given electrometer indication is when the given surface is a circular plate, that is to say, when the boundary is a minimum, and the greatest when extended into a right line of small width—that is, when the boundary is a maximum. In the union of two similar surfaces by a boundary contact, as for example two circular plates, two spheres, two rectangular plates, &c., we fail to obtain twice the charge of one of them taken separately. In either case we fail to decrease the intensity (the quantity being constant) or to increase the charge (the intensity being constant), it being evident that whatever decreases the electrometer indication or intensity must increase the charge—that is to say, the quantity which can be accumulated under the given intensity. Conversely, whatever increases the electrometer decreases the charge—that is to say, the quantity which can be accumulated under the given intensity.

10. If the grouping or disposition of the electrical particles, in regard to surrounding matter, be such as not to materially influence external induction, then the boundary extension of the surface may be neglected. In all similar figures, for example, such as squares, circles, spheres, &c., the electrical boundary is, in relation to surrounding matter, pretty much the same in each, whatever be the extent of their respective surfaces. In calculating the charge, therefore, of such surfaces, the boundary extensions may be neglected, in which case their relative charges are found to be as the square roots of the surfaces only; thus the charges of circular plates and globes are as their diameters, the charges of square plates are as their sides. In rectangular surfaces also, having the same boundary extensions, the same result ensues, the charges are as the square roots of the surfaces. In cases of hollow cylinders and globes, in which one of the surfaces is shut out from external influences, only one-half the surface may be considered as exposed to external inductive action, and the charge will be as the square root of half the surface, that is to say, as the square root of the exposed surface. If, for example, we suppose a square plate of any given dimensions to be rolled up into an open hollow cylinder, the charge of the cylinder will be to the charge of the plate into which we may suppose it to be expanded as $1 : \sqrt{2}$. In like manner, if we take a hollow globe and a circular plate of twice its diameter, the charge of the globe will be to the charge of the plate also as $1 : \sqrt{2}$, which is the general relation of the charge of closed to open surfaces of the same extension. The charge of a square plate to the charge of a circular plate of the same diameter was found to be as 1 : 1·13; according to Cavendish it is as 1 : 1·15, which is not far different. It is not unworthy of remark that the electrical relation of a square to a circular plate of the same diameter, as determined by Cavendish nearly a century since, is in near accordance with the formulæ $C = \sqrt{S}$ above deduced.

11. The author enumerates the following formulæ as embracing the general laws of quantity, surface, boundary extension, and intensity, practically useful in deducing the laws of statical electrical force.

Symbols.

Let C = electrical charge; Q = quantity; E = intensity, or electrometer indication; S = surface; B = boundary extension, or perimeter; Δ = direct induction; δ = reflected induction; F = force; D = distance.

Formulæ.

$C \propto S$, when S and B vary together.
$C \propto Q$, E being constant, or equal 1.
$C \propto \sqrt{S}$, B being constant, or equal 1.
$C \propto \sqrt{B}$, S being constant, or equal 1.
$C \propto \sqrt{S.B}$, when S and B vary together.

$E \propto \frac{1}{S.B.}$ (Q, being constant), for all plane rectangular surfaces.

$E \propto \frac{1}{B}$, S being constant, or equal one.

$E \propto \frac{1}{S}$, B being constant, or equal 1.

$E \propto \frac{1}{S^2}$, when S and B vary together.

$C \propto \sqrt{\frac{1}{E}}$ . . . .

$E \propto Q^2$, S being constant, or equal 1.

$C \propto \frac{Q^2}{S^2}$ . . . .

In square plates, $C \propto$ with side of square.
In circular plates, $C \propto$ with diameter.
In globes, $C \propto$ with diameter.
Δ, or induction, $\propto$ S, all other things remaining the same.
The same for δ, or reflected induction.
In circular plates, globes, and closed and open surfaces,

$$E \propto \frac{1}{S}; \text{ or as } \frac{1}{\Delta}.$$
$$F (= E) \propto Q^2.$$
$$F \text{ or } E \propto \frac{1}{D^2}, \text{ S being constant.}$$

Generally we have $F \propto \frac{Q^2}{D^2}$.

12. The author calculates from these laws of charge for circles and globes, a series of circular and globular measures of definite values, taking the circular inch or globular inch as unity, and calling, after Cavendish, a circular plate of an inch in diameter, charged to saturation, a circular inch of electricity; or otherwise charged to any degree short of saturation, a circular inch of electricity under a given intensity. In like manner he designates a globe of an inch in diameter a globular inch of electricity.

In the following Table are given the quantities of electricity contained in circular plates and globes, together with their respective intensities for diameters varying from ·25 to 2in.; a circular plate of an inch diameter and $\frac{1}{5}$th of an inch thick being taken as unity, and supposed to contain 100 particles or units of charge.

Diameters, or units of charge.	Circle.		Globe.	
	Particles.	Intensity.	Particles.	Intensity.
0·25	25	0·062	35	0·124
0·50	50	0·250	70	0·500
0·75	75	0·560	105	1·120
1·00	100	1·000	140	2·000
1·25	125	1·560	175	3·120
1·40	140	1·960	196	3·920
1·50	150	2·250	210	4·500
1·60	160	2·560	224	5·120
1·75	175	3·060	245	6·120
2·00	200	4·000	280	8·000

13. The experimental investigations upon which these elementary data depend, constitute a second part of this paper. The author here enters upon a brief review of his hydrostatic electrometer, as recently perfected and improved, it being essential to a clear comprehension of the laws and other physical results arrived at.

In this instrument the attractive force between a charged and neutral disk, in connection with the earth, is hydrostatically counterpoised by a small cylinder of wood accurately weighted, and partially immersed in a vessel of water. The neutral disk and its hydrostatic counterpoise are freely suspended

over the circumference of a light wheel of 2·4in. in diameter, delicately mounted on friction-wheels, so as to have perfectly free motion, and be susceptible of the slightest force added to either side of the balance. Due contrivances are provided for measuring the distance between the attracting disks. The balance-wheel carries a light index of straw reed, moveable over a graduated quadrantal arc, divided into 90° on each side of its centre. The neutral attracting plate of the electrometer is about $1\frac{1}{2}$in. in diameter, and is suspended from the balance-wheel by a gold thread, over a similar disk, fixed on an insulating rod of glass, placed in connection with any charged surface the subject of experiment. The least force between the two disks is immediately shown by the movement of the index over the graduated arc in either direction, and is eventually counterpoised by the elevation or depression in the water of the hydrostatic cylinder suspended from the opposite side of the wheel. The divisions on the graduated quadrant correspond to the addition of small weights to either side of the balance, which stand for or represent the amount of force between the attracting plates at given measured distances, with given measured quantities of electricity. This arrangement is susceptible of very great accuracy of measurement.

The experiment requires an extremely short time for its development, and no calculation is necessary for dissipation. The author carefully describes the manipulation requisite in the use of this instrument, together with its auxiliary appendages. He considers this electrometer, as an instrument of electrical research, quite invaluable, and peculiarly adapted to the measurement of electrical force.

14. Having fully described this electrometer, and the nature of its indications, certain auxiliary instruments of quantitative measure, to be employed in connection with it, are next adverted to.

First, the construction and use of circular and globular transfer measures given in the preceding Table, by which given measured quantities of electricity may be transferred from an electrical jar (charged through a unit jar from the conductor of an electrical machine) to any given surface in connection with the electrometer. The electrical jar he terms a *quantity jar*, the construction and employment of which is minutely explained; as also the construction and employment of the particular kind of unit jar he employs.

15. Two experiments (1 and 2) are now given in illustration of this method of investigation.

Experiment 1 developes the law of attractive force as regards quantity; which is found to vary with the square of the number of circular or globular inches of electricity, transferred to a given surface in connection with the fixed plate of the electrometer, the distance between the attracting surfaces being constant.

Experiment 2 demonstrates the law of force as regards distance between the attracting surfaces, the quantity of electricity being constant; and by which it is seen that the force is in an inverse ratio of the square of the distance between the attracting plates, the plates being susceptible of perfect inductive action. From these two experiments, taken in connection with each other, we derive the following formula, $F \propto \frac{Q^2}{D_2}$; calling F the force, Q the quantity, and D the distance. It is necessary, however, to observe that this formula only applies to electrical attractive force between a charged and neutral body in connection with the earth, the two surfaces being susceptible of free electrical induction, both direct and reflected.

16. The author now refers to several experiments (3, 4, 5, and 6), showing that no sensible error arises from the reflected inductive action of the suspended neutral disk of the electrometer, or from the increased surface attendant on the connection of the surface under experiment with the fixed plate of the electrometer; as also, that it is of no consequence whether the suspended disk be placed immediately over the fixed attracting plate of the electrometer, or over any point of the attracting surface in connection with it.

17. Having duly considered these preliminary investigations, the author now proceeds to examine experimentally the laws of surface and boundary as regards plane rectangular surfaces, and to verify the formulæ $C = \sqrt{S.B}$, and $E = \frac{1}{S.B}$; in which C = charge, E = intensity, S = surface, and B = boundary.

For this purpose a series of smoothly-polished plates of copper were employed, varying from 10in. square to 40in. long by 2·5 to 6in. wide, and about $\frac{1}{8}$th of an inch thick, exposing from 100 to 200 square inches of surface.

The charges (1) of these plates were carefully determined under a given electrometer indication, the attracting plates being at a constant distance.

Experiment 7. In this experiment, a copper plate 10in. square is compared with a rectangular plate 40in. long by 2·5in. wide.

In these plates the surfaces are each 100 square inches, whilst the boundaries are 40 and 85in. The boundaries may be taken, without sensible error, as 1 : 2, whilst the surfaces are the same.

On examining the charges of these plates, charge of the square plate was found to be 7 circular inches, under an intensity of 10°. Charge of the rectangular plate 10 circular inches nearly, under the same intensity of 10°. The charges therefore were as 7 : 10 nearly, that is, as 1 : 1·4 nearly; being the square roots of the boundaries, that is, as $1 : \sqrt{2}$.

Experiment 8. A rectangular plate 37·5in. long by 2·7in. wide, surface 101 square inches, boundary 80·5in., compared with a rectangular plate 34·25in. long by 6in. wide, surface 205 square inches, boundary 80·5in.

Here the boundaries are the same, whilst the surfaces may be taken as 1 : 2.

On determining the charges of these plates, charge of the rectangular plate, surface 101 square inches was found to be 8·5 circular inches under an intensity of 8°. Charge of the plate with double surface = 205 square inches, was found to be 12 circular inches under the same intensity of 8°; that is to say, whilst the surfaces are as 1 : 2, the charges are as 8·5 : 12 nearly, or as the square roots of the surfaces, that is, as $1 : \sqrt{2}$.

Experiment 9. A rectangular plate 26·25in. long by 4in. wide, surface 105 square inches, boundary 60·5, compared with a rectangular plate 40in. long by 5in. wide, surface 200 square inches, boundary 90in.

Here the surfaces are as 1 : 2 nearly, whilst their boundaries are as 2 : 3.

Charge of the rectangular plate surface = 105 square inches, 7 circular inches under an intensity of 10°. Charge of rectangular plate surface 200 square inches 12 circular inches, under the same intensity of 10°. The charges, therefore, are as 7 : 12 nearly, or as 1 : 1·7, being as the square roots of the surfaces multiplied into the square roots of the boundaries very nearly.

Experiment 10. A square plate 10in. square, surface 100 square inches, boundary 40in., compared with a rectangular plate 40in. long by 5in. wide, surface 200 square inches, boundary 90 inches.

Here the surfaces are double of each other, and the boundaries also double each other, or so nearly as to admit of their being considered double of each other. Charge of square plate 6 circular inches, under an intensity of 10°. Charge of rectangular plate 12 circular inches, under the same intensity of 10°. The charges, therefore, are as the square roots of the surfaces and boundaries conjointly, according to the formula $C = \sqrt{S.B}$, as also verified in the preceding experiment 9.

A double surface, therefore, having a double boundary, takes a double charge, but not otherwise. Neglecting all considerations of the boundary, therefore, the surface and boundary varying together, the charge in this case will be as the surface directly.

18. The author having verified experimentally the laws of surface and boundary, as regards plain rectangular surfaces, proceeds to consider the charges of square plates, circular plates, spheres, and closed and open surfaces generally.

Experiment 11. Plate 10in. square, surface 100 square inches, boundary 40in., compared with a similar plate 14in. square, surface 196 square inches, boundary 56in. Here the surfaces are as 1 : 2 nearly, whilst the boundaries are as $1 : \sqrt{2}$ nearly.

In this case charge of square plate, surface 100 square inches, was found to be 8 circular inches under an intensity of 10°. Charge of the plate, surface 196 square inches, 11 circular inches, under the same intensity of 10°. Here the charges are as 8 : 11, whilst the surfaces may be taken as 1 : 2, that is to say (neglecting the boundary), the charges are as the square roots of the surfaces, according to the formula $C = \sqrt{S}$.

On examining the intensities of these plates, they were found to be inversely as the surfaces; thus 8 circular inches upon the plate, surface 100, evinced an intensity of 10°; 8 circular inches upon the plate, surface 196, evinced an intensity of 5° only, or $\frac{1}{2}$ the former, according to the formula $E = \frac{1}{S}$.

Experiment 12. A circular plate of 9in. diameter, surface 63·6 square inches, compared with a circular plate of 18in., or double that diameter, surface 254 square inches. Here the surfaces are as 1 : 4, whilst the boundaries or circumferences are as 1 : 2.

Charge of 9-inch plate, 6 circular inches, under an intensity of 10°. Charge of 18-inch plate, 12 circular inches, under the same intensity of 10°. Here the charges are as 1 : 2, whilst the surfaces are as 1 : 4; neglecting the difference of boundary, therefore, the charges, as in the preceding experiments, are as the square roots of the surfaces.

On examining the intensities of these plates, they were found to be inversely as the surfaces; thus 6 circular inches upon the 9in. plate evinced an intensity of 10°, as just stated; 6 circular inches upon the 18in. plate had only one-fourth the intensity, or 2°·5; being inversely as the surfaces, according to the formula $E = \frac{1}{S}$.

Experiment 13. A circular plate of 9in. diameter, surface 63·6 square inches, compared with a circular plate of 12·72in. diameter, surface 127·2 square inches. Here the surfaces are as 1 : 2.

Charge of 9in. plate (surface 63·6 square inches), 5 circular inches, under an intensity of 8°. Charge of 12·72in. plate (surface 127·2 square inches), 7 circular inches, under the same intensity of 8°. The charges here are as 5 : 7, while the surfaces are as 1 : 2; that is to say (neglecting the boundaries), the charges are as the square roots of the surfaces.

On examining the intensities of these plates, they were found to be, as in the preceding experiments, inversely as the surfaces.

Experiment 14. Comparison of a sphere of 4·5in. diameter, surface 63·5 square inches, with a sphere of 9in., or double that diameter, surface 254 square inches

Charge of sphere 4·5in. diameter (surface 63·5 square inches), 4 circular inches, under an intensity of 9°. Charge of sphere of 9in. diameter (surface 254 square inches), 8 circular inches, under the same intensity of 9°. Here the charges are as 1 : 2, whilst the surfaces are as 1 : 4. The charges, therefore, are as the square roots of the surfaces, or as $1 : \sqrt{4}$.

On examining the intensities of these spheres, they were found to be as the surfaces inversely, or very nearly; being as 2°·5 and 9° respectively.

Experiment 15. Circular plate of 9in. diameter compared with a sphere of the same diameter. Here the actual surfaces are 63·6 square inches for the plate, and 254 square inches for the sphere, being as 1 : 4. We have to observe, however, that one surface of the sphere is closed or shut up, consequently the exposed surfaces, electrically considered, neglecting one-half the surface of the sphere as being closed, are as 1 : 2; and the exposed surface of the plate is exactly one-half the exposed surface of the sphere.

Charge of plate 8 circular inches, under an intensity of 12°. Charge of sphere 11 circular inches, under the same intensity of 12°. The charges, therefore, are as 8 : 11, or as 1 : 1·4; the exposed surfaces being as 1 : 2. The charges, therefore, are as the square root of the exposed surfaces.

On examining the intensities of the plate and sphere, they were found to be in an inverse ratio of the exposed surfaces, as in the former experiments.

Experiment 16. Comparison of a sphere of 7in. diameter with a circular plate of 14in. or double that diameter. In this case the inner and outer surfaces of the sphere, taken together, are actually the same as the two surfaces of the plate. The inner surface of the sphere being closed, however, as in the last experiment, the surfaces of the sphere and plate, electrically considered, are therefore not equal, and the surface of the plate is twice the surface of the sphere. The surfaces, therefore, open to external induction are as 2 : 1.

On examining the charges of the plate and sphere, they were found to be as 10 : 14, or as 1 : 1·4; charge of sphere being 10 circular inches, under an intensity of 20°, and charge of plate being 14 circular inches, under the same intensity of 20°. The charge of the sphere, therefore, as compared with the charge of the plate, is as 1 : $\sqrt{2}$, that is, as the square roots of the exposed surfaces.

On examining the intensities of the sphere and plate, they were found to be, as in the preceding experiments, in an inverse ratio of the exposed surfaces. We cannot, therefore, conclude, as already observed (4), that the capacity of the plate is twice that of the sphere.

19. The following experiments are further adduced in support of the preceding:—

Experiment 17. A copper plate 10in. square, compared with the same plate rolled up into an open hollow cylinder, 10in. long by 3·2in. diameter. Here, as in the last experiments, although the surfaces are actually the same, yet, electrically considered, the plate has twice the surface of the cylinder, one surface of the cylinder being shut up.

On examining the charges of the cylinder and plate, they were found to be, as in the preceding experiments, as 1 : $\sqrt{2}$; that is, as the square roots of the exposed surfaces, and the intensities in an inverse ratio of the surfaces, which seems to be a general law for closed and open surfaces.

Experiment 18. A hollow copper cube, side 5·7in., surface 195, compared with a hollow copper sphere of diameter equal side of cube, surface 103 square inches nearly.

On examining the charges of the sphere and cube, they were found to be as 9 : 10, nearly; charge of the sphere being 9 circular inches, under an intensity of 10°, and charge of cube 10 circular inches, under the same intensity of 10°. The charges of a cube, and of a sphere whose diameter equals the side of the cube, approach each other, notwithstanding the differences of the surfaces, owing to the six surfaces of the cube not being in a disjointed or separated state.

20. The author observes, in conclusion, that the numerical results of the foregoing experiments, although not in every instance mathematically exact, yet upon the whole were so nearly accordant as to leave no doubt as to the law in operation. In would be in fact, he observes, assuming too much to pretend in such delicate experiments to have arrived at nearer approximations than that of a degree or two of the electrometer, or within quantities less than that of ·25 of a circular inch. If the manipulation, however, be skilfully conducted, and the electrical insulations perfect, it is astonishing how rigidly exact the numerical results generally come out.

INSTITUTION OF CIVIL ENGINEERS.

The Council have awarded the following premiums for the Session 1863-64:—

1. A Telford Medal, and the Manby Premium, in Books, to George Henry Phipps, M. Inst. C.E., for his paper "On the Resistances to Bodies passing through Water."

*2. A Telford Premium, in Books, to John Baldry Redman, M. Inst. C.E., for his paper "On the East Coast, between the Thames and the Wash Estuaries."

3. A Telford Medal, and a Telford Premium, in Books, to William Lloyd, M. Inst. C.E., for his "Description of the Santiago and Valparaiso Railway, Chile, South America; with remarks upon resistances from curves on railways, and upon coal burning locomotives."

*4. A Telford Premium in Books, to William Parkes, M. Inst. C.E., for his "Description of Lighthouses lately erected in the Red Sea."

5. A Telford Medal, to M. Pernolet (of Paris), for his paper "On the Means of Utilising the Products of the Distillation of Coal, so as to reduce the price of Coke; with descriptions of the Ovens, and of the best processes in use in Great Britain and on the Continent, in the Manufacture of Coke."

6. A Watt Medal, and a Telford Premium, in Books, to Thomas Sopwith, Junior, Assoc. Inst. C.E., for his paper "On the Actual State of the Works on the Mont Cenis Tunnel, Victor Emmanuel Railway, and Description of the Machinery Employed."

*7. A Watt Medal, to William Bridges Adams, for his paper "On the Impedimental Friction between Wheel Tires and Rails, with plans for Improvement."

8. A Watt Medal, to James Cross, for his paper "On the Structure of Locomotive Engines for ascending Steep Inclines, especially when in conjunction with Sharp Curves on Railways."

*9. A Telford Premium, in Books, to John Mortimer Heppel, M. Inst. C.E., for his paper "On the Closing of Reclamation Banks."

10. A Telford Premium, in Books, to George Rowdon Burnell, F.G.S.. for his paper "On the Machinery employed in sinking Artesian Wells on the Continent."

The following is the list of subjects for premiums for the Session 1864-65:—

The Council invite communications on the subjects comprised in the following list, as well as upon others; such as, 1°, Authentic Details of the Progress of any Work in Civil Engineering, as far as absolutely executed (Smeaton's Account of the Eddystone Lighthouse may be taken as an example); 2°, Descriptions of Engines and Machines of various kinds; or, 3°, Practical Essays on Subjects connected with Engineering, as, for instance, Metallurgy. For approved Original Communications, the Council will be prepared to award the Premiums arising out of special funds devoted for the purpose.

1. On the Decay of Materials in Tropical Climates, and the methods employed for arresting and preventing it.
2. On the Theory and Details of Construction of Metal and Timber Arches, and of Wrought Iron Girder Bridges.
3. On Land-slips, with the best means of preventing, or arresting them, with examples.
4. On the results of contrivances for facilitating the Driving of Tunnels, or Drifts in Rock.
5. On the Principles to be observed in Laying-out lines of Railway through mountainous countries, with examples of their application in the Alps, the Pyrenees, the Indian Ghauts, the Rocky Mountains of America, and similar cases.
6. On the best means of preserving Railways in Alpine countries from interruptions from snow.
7. On the Principles to be observed in the designing and arrangement of Terminal and other Railway Stations, Repairing Shops, Engine-sheds, &c., with reference to the traffic and the rolling stock.
8. On Railway Ferries, or the Transmission of Railway Trains entire across Rivers, Estuaries, &c.
9. On Locomotive Engines for ascending Steep Inclines, especially when in combination with sharp curves, on Railways.
10. On the Working of Railways, with frequent stations.
11. On the Results of the Application of Giffard's Injector to the Boilers of Locomotive and other Engines.
12. On the Working Expenses of Railways, and the influence on these of the original design and construction.
13. On the Pneumatic System for the conveyance of Passengers and Goods.
14. On the Results of a series of observations on the Flow of Water from the Ground, in any large district; with accurately-recorded Rain-Gauge Registries, in the same locality, for a period of not less than twelve months.
15. On the Construction of Catch-water Reservoirs in Mountain Districts, for the supply of Towns, or for Manufacturing purposes.
16. Accounts of existing Water-works; including the source of supply, a description of the different modes of collecting and filtering, the distribution throughout the streets of Towns, and the general practical results.
17. On the Structural Details, and the Results in Use, of Apparatus for the Filtration of large volumes of water.
18. On the Drainage and Sewerage of large Towns; exemplified by accounts of the systems at present pursued, with regard to the level and position of the outfall, the form, dimensions, and material of the sewers, the prevention of emanations from them, the arrangements for connecting the house drains with the public sewers, the best means of limiting the contamination of rivers from the sewage discharged into them, and the disposal of the sewage, whether in a liquid form, as irrigation, or in a solid form, after deodorisation.
19. On the most suitable Materials for, and the best mode of Formation of, the Surfaces of the Streets of large Towns.
20. On the Construction of Gas Works, the most economical system of distribution of the Gas, and the best modes of Illumination in Streets and Buildings.
21. A History of any Fresh Water Channel, Tidal River, or Estuary,—accompanied by plans and longitudinal and cross sections of the same, at various periods, showing the alterations in its condition,—including notices of any works which may have been executed upon it, and of the effects of the works; particularly of the relative value of Tidal and Fresh Water, of the effect of Enclosures from the Tidal Area upon the general regime, of Sluicing where applied to the improvement of the entrance or the removal of a Bar, and of Groynes, or Parallel Training Walls. Also, of Dredging, with a description of the Machinery employed, and the cost of raising and depositing the material.
22. On the Results of a Series of Observations, illustrative of the modifications which the tidal wave undergoes in its passage up and down a river, or estuary.
23. On the Construction of Tidal, or other Dams, in a constant, or variable depth of water; and on the use of wrought iron in their construction.
24. A History of any Harbour, or Dock, including the reasons for selecting the site, the mode of construction adopted, and the subsidiary works for the convenience of shipping, and for commercial purposes, with the cost, &c.
25. On Graving Docks and mechanical arrangements having a similar object, with the conditions determining their relative applicability in particular cases, as dependent on the rise of tide, the depth of water, and other circumstances.
26. On the Arrangement and Construction of Floating Landing-stages, for passenger and other traffic, with existing examples.
27. On the different systems of Swing, Lifting, and other opening Bridges, with existing examples.
28. On the Construction of Lighthouses, their Machinery, and Lighting Apparatus; with notices of the methods in use for distinguishing the different Lights.
29. On the Measure of Resistance to Steam Vessels at high Velocities.
30. On the results of the use of Tubular Boilers, and of Steam at an increased pressure, with, or without superheating, for Marine Engines, noticing particularly the difference in weight and in speed, in proportion to the Horse Power and the Tonnage.

* Have previously received Telford Medals.

31. On the Results of the Employment of Steam Power on Canals, and of other measures for the Improvement of Canals as a means of conveyance for heavy traffic.

32. On the relative advantages of the Principle of Expansion, as applied in the Single long-stroke Cylinder Engine, in the Double Cylinder Engine, and in the Three Cylinder Engine; and on the adaptation of the two latter to marine purposes.

33. On the Principles and Varieties of Construction of Blast Engines, with British and Foreign Examples.

34. On the construction of, and the comparative duty performed by, modern Pumping Engines for rising Water, for the supply of Towns, or for the Drainage of Mines; noticing in the latter case, the depth and length of the underground workings, the height of the surface above the sea, the geological formation, the contiguity of streams, &c.

35. On Turbines and other Water Motors of a similar character; and their construction and performance, in comparison with Water-wheels.

36. On the present systems of Smelting Iron Ores; and on the conversion of cast-iron into the malleable state, and of the manufacture of iron generally, comprising the distribution and management of Iron Works.

37. On the Manufacture of Iron for Rails and Wheel Tires, having special reference to the increased capability of resisting lamination and abrasion; and accounts of the Machinery required for rolling heavy Rails, Shafts, and bars of Iron of large sectional area.

38. On the Bessemer and other processes of Steel-making; on the present state of the Steel Manufacture on the Continent of Europe; and on the employment of castings in Steel for Railway Wheels and other objects.

39. On the Use of Steel for the Tires and Cranked Axles of Locomotive Engines, especially with reference to its durability and the cost of repairs, as compared with Iron of acknowledged good quality; and on the use of Steel Bars and Plates generally in Engine-work and Machinery, for Boilers and for Shipbuilding, as well as for Bridges.

40. On the safe working strength of Iron and Steel, including the results of experiments on the Elastic Limit of long bars of Iron, and on the rate of decay by rusting, &c., and under prolonged strains.

41. On the Transmission of Electrical Signals through Submarine Cables.

42. On the present relative position of English and Continental Engineering Manufactories, especially with reference to their comparative positions in respect of the cost, and the character of the work produced.

43. Memoirs and accounts of the Works and Inventions of any of the following Engineers:—Sir Hugh Middleton, Arthur Wolf, Jonathan Hornblower, Richard Trevithick, William Murdoch (of Soho), Alexander Nimmo, and John Rennie.

Original Papers, Reports, or designs, of these, or other eminent individuals, are particularly valuable for the Library of the Institution.

The competition for Premiums is not confined to Members, or Associates of the Institution, but is equally open to all persons, whether natives or foreigners.

The Council will not consider themselves bound to award any Premium, should the Communication not be of adequate merit, but they will award more than one Premium, should there be several communications on the same subject deserving this mark of distinction.

The Communications must be forwarded, on or before the 1st of February, 1865, to the house of the Institution, No. 25, Great George-street, Westminster, S.W., where copies of this paper, and any further information, may be obtained.

INSTRUCTIONS FOR PREPARING COMMUNICATIONS.

The Communications should be written in the impersonal pronoun, and be legibly transcribed on foolscap paper, about thirteen inches by eight inches, the lines being three-quarters of an inch apart, on the one side only, leaving a margin of one inch and a half in width on the left side, in order that the sheets may be bound.

The Drawings should be on mounted paper, and with as many details as may be necessary to illustrate the subject. Enlarged Diagrams, to such a scale that they may be clearly visible, when suspended on the walls of the Theatre of the Institution, at the time of reading the communication, should be sent for the illustration of any particular portions.

Papers which have been read at the Meetings of other Scientific Societies, or have been published in any form, cannot be read at a Meeting of the Institution, nor be admitted to competition for the Premiums.

ON THE DECAY OF MATERIALS IN TROPICAL CLIMATES, AND THE METHODS EMPLOYED FOR ARRESTING AND PREVENTING IT.

By G. O. MANN.

The facts and experience recorded in this Paper had reference particularly to the empire of Brazil, the Author being the Resident Engineer and Locomotive Superintendent of the Recife and San Francisco Railway Company. It was stated that the temperature varied less probably than in any other quarter of the globe; but the seasons, which it was believed influenced the decay of materials to a greater extent than the temperature, were not so regular. Thus, the rainfall ranged from 60 inches to 120 inches per annum, and this did not occur at any particular period, though a certain peculiarity in the climate, excessive heat combined with much moisture, was noticeable more or less throughout the year.

It had been found, on the Pernambuco Railway, that the half-round intermediate sleepers, of timber from the North of Europe, creosoted, were in a better state of preservation than the square sawn, joint sleepers of the same material; still, after seven years' trial, it was evident that creosote, when properly applied to suitable descriptions of timber, would prevent decay. In white-sand ballast, since the opening of the first section of the line in 1858, the half-round sleepers had not suffered a depreciation of more than 1 per cent., while the square sawn sleepers had experienced a depreciation of not less than 50 per cent. On the other sections of the line, sleepers of native timber were employed, with unsatisfactory results; this was due, it was asserted, to the timber having been cut at unfavourable seasons, and to the sleepers having been laid in a green state, owing to the rapid progress of the works not allowing time for them to become dry. The author, after nearly seven years' experience, was confident, however, that properly selected timber of the country would be found more durable than any description of wooden sleeper yet imported. It was advisable, in order to prevent decay, to cut the timber during the dry season, to select large and full-grown trees, to remove the whole of the bark and sapwood, leaving the heart of the timber only, and not to expose the sleepers in the sun when fresh cut, but to stack them in open piles under cover, through and about which the air could freely circulate for a few months. The cost of such sleepers delivered at the stations on the Pernambuco Railway, was at present 2*s.* 7*d.* each, the scantling being 10in. by 5in. by 9ft. Imported creosoted sleepers had invariably cost double that amount.

Respecting timber in general, it was remarked that good timber for building purposes abounded in Brazil, in the greatest variety. Many kinds were impervious to the white ant, which insect generally selected the more porous descriptions, and particularly those in contact with the earth. In dry places, and with a free circulation of air, the white ant did not, in preference, select timber thus situated for its ravages; and it was found that the roofs of buildings, of good and well seasoned native timber, resisted for an indefinite period, both the climate and the white ant. Latterly it had been the practice to "pay" over, with coal tar, the ends of all timber built into the gables of buildings, or in any other position in which it was buried, or excluded from the air, and so far apparently with beneficial results. Two specimens were exhibited of the piles of the old Recife wooden bridge, which had been constructed in 1614, in proof of the durability of native timber; and it was asserted that, with proper precautions, no foreign timber would be found able to compete in the tropics with that of native growth.

The only examples of iron bridges in the province of Pernambuco, except that of St. Isabel, completed in 1863, were those belonging to the railway. The result of a careful examination of four of these structures, after they had been erected six years, was to show that the cast-iron pipe piles, forming the piers, were likely to remain good for a considerable period; and that the upper structures of wrought iron would also last well with ordinary attention. The only parts apparently affected were the wrought iron bracings, and the bolts and nuts below high-water mark. With regard to the preservation of iron bridges, and of iron work in general, for the tropics, care ought to be taken to insure the iron being perfectly dry before the paint, or any other composition, was laid on. Coal tar had been found to afford a most efficient protection. It was advisable that all small pieces should, before being shipped, be heated to a low temperature, and then brushed with and dipped in tar; the larger parts should be well cleansed, and the tar laid on while hot. Where tar was objectionable, linseed oil might be applied in the same way, and over this there should be a thin coating of zinc paint.

With regard to building materials, stone, wherever it could be obtained at a reasonable price, should be preferred, for the abutments and piers of bridges. Stone imported from Portugal, for facing the churches, and in a few old Dutch works of the seventeenth century, had been found to be very durable. Great caution was necessary in the selection of bricks, as those made near the seaboard, with brackish water, were very susceptible to the weather, and mouldered away rapidly when exposed. As it was all but impossible to obtain thoroughly well-burnt bricks in large quantities, all brickwork near to the sea-coast required to be protected with plaster from the first, and in the interior this was ultimately necessary, or else a thick coating of lime whitewash might be given from time to time. Tiles made of similar, though where obtainable of better clay, when well burnt, were scarcely affected by the weather, either on the seaboard, or in the interior. Rafters were selected from young trees, and if of the proper quality of timber, had considerable duration. Laths were in nearly all cases made from the sap wood of "imbcriba," perhaps the hardest and most durable description of timber in Brazil.

The permanent way keys, used for renewals since the opening of the Pernambuco Railway in 1858, had been cut from native timber, of a remarkably close nature, which did not shrink, as the imported keys were found to do. The rails oxidised when left near to the sea-coast, so that it was desirable to remove them to the places where they were to be used, as soon as possible. The motion of the trains appeared to prevent rust from forming on the rails, but owing to the high temperature they were always at during the day, and to the constant passage of the trains, there was a tendency in them to become flattened. About ten miles of the line had been laid with Greaves's "pot" sleepers, as to the durability of which in the tropics there could be no question, but they were found to make a rigid road, even in fine sand ballast. This portion of the line had been improved, by introducing fish plates, and suspending the joints. The railway carriages were made with a strong wrought iron under-frame; the body and the inside lining were of teak; and the outside panels were of papier-maché. These carriages were in excellent preservation, after six years' work and exposure to the sun and rain.

MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

At the ordinary monthly meeting of this association, held on October 25th, 1864, the chief engineer presented his report. This report was a double one, embracing the month of September as well as that of October.

"During the last two months 565 engines have been examined, and 692 boilers, 43 of the latter being examined specially, and 7 of them tested with hydraulic pressure. Of the boiler examinations, 608 have been external, 21 internal, and 63 thorough. In the boilers examined, 276 defects have been discovered, 2 of them being dangerous. Details of these will be found in the following tabular statement:—

Description.	Number of Cases met with.		
	Dangerous.	Ordinary.	Total.
Defects in Boiler.			
Furnaces out of shape	...	4	4
Fracture	...	10	10
Blistered plates	...	6	6
Corrosion—Internal	...	10	10
Ditto External	...	23	23
Grooving—Internal	...	3	3
Ditto External	...	6	6
Total number of defects in boiler	...	62	62
Defective Fittings.			
Feed apparatus out of order	...	2	2
Water Gauges ditto	...	11	11
Blow Out Apparatus ditto	...	21	21
Fusible Plugs ditto	1	9	10
Safety Valves ditto	1	3	4
Pressure Gauges ditto	...	24	24
Total number of Defective Fittings	2	70	72
Omissions.			
Boilers without Glass Water Gauges	...	18	18
Ditto Pressure Gauges	...	2	2
Ditto Blow Out Apparatus	...	49	49
Ditto Feed Back Pressure Valves	...	70	70
Total number of Omissions	...	139	139
Cases of Over Pressure	...	3	3
Cases of Deficiency of Water	...	...	...
Gross Total	2	274	276

"The case of a dangerously defective fusible plug, given in the preceding table, is one of importance.

"The construction of plug referred to was as follows:—The fusible metal was cast in the shape of a flat washer, a trifle larger in diameter, and a little thicker than a penny piece. To fix this washer in its place it had merely to be dropped into its brass socket or cup attached to the furnace crown, and then a ring cap screwed over it, so that by simply unscrewing this cap, the fusible washer was released, and could thus be removed and renewed at pleasure. With a view of making this washer more sensitive, and also of insuring a large opening through it in the event of the water in the boiler running short, a copper button was inserted in its centre. It was proposed to supply the plugs of this description with a number of spare washers, so that the fusible metal could be renewed at regular intervals. The whole arrangement appeared so simple, and the facility for renewing the fusible metal so great, that these plugs, although of very recent introduction, were yet coming rapidly into general use. They have, however, proved very dangerous in practice, a number of failures having occurred.

"These flat fusible washers have proved too weak to resist the pressure of steam, and have been punched completely through. In the instance referred to, the boiler, which had two furnaces, was a new one, and had not been at work many days. The pressure of the steam was 45lb. to the inch, and there was plenty of water over the furnace crowns the moment the plug gave way. The rush of water put out the fire and scattered the hot ashes; the plug in the other furnace did not give way, and the fire in it continued to burn, while it was some time before it could be approached and drawn, in consequence of the rush of steam and water, so that the crown plates narrowly escaped injury from overheating.

"This is by no means an individual instance of the failure of this description of plug. It is the second that has recently occurred to our own members; while several others have come to my knowledge. It has been attempted, most unfairly, to throw the blame of these repeated failures upon the boiler attendants, whereas there can be no question that the fault lies in the mal-construction of the plug.

"It should be added that the makers have offered to give a public trial of the plug, in order to establish its merits.

"Explosions.

"No. 20 explosion happened at a saw mill, to a boiler of a very small size.

"The boiler was of Cornish construction, had a single flue, was internally-fired, and set on a midfeather wall. Its length was 7ft., and its diameter 3ft. 6in.; while it was usually worked at a pressure of from 35lb. to 50lb. per square inch.

"It appeared, on examination subsequent to the explosion, that there had been a continual leakage from the seams at the bottom of the boiler, the water from which was ponded by the brickwork of the midfeather wall, and held in contact with the plates. These were in consequence so eaten away by corrosion, that they were reduced in a continuous line of 4ft. 6in. in length to the thickness of a sixpence, while many of the rivet heads at the bottom of the boiler were eaten off. It is not surprising, therefore, that the boiler should have rent as it did along the bottom, almost from one end to another, and that it should have been thrown up into the air for a considerable height. It fell in the adjoining premises, and at a distance of about 40 yards from its original seating.

"No. 21 explosion, by which three lives were lost, occurred to a colliery boiler.

"I found that the explosion had occurred to a boiler which formed one of a series of six, all of them being of plain cylindrical egg-ended construction, externally-fired, and set with single direct or flash flues. Each of these boilers lay east and west, while the series extended north and south, the boiler which exploded being the fourth from the north end of the series at which stood the engine-house, and the third from the south; while the furnace was at the east end of the boiler in question, and the chimney at the west.

"The boiler was plated longitudinally throughout, and though its age could not be precisely ascertained, it was evidently considerable, the boiler being stated to be out of date, and it is probable that it was not less than 25 years old. Its length was 25ft., its diameter 6ft., and the thickness of the plates three-eighths of an inch, while the pressure at which it was worked was 35lb. to the square inch. The fittings appear to have been adequate, while the safety valves were ample, since there were two on each boiler, one of them being $3\frac{1}{4}$in. in diameter, and the other 5in.

"The boiler rent at one of the longitudinal seams of rivets situated a little below the water line, and at the right hand, or north side of the shell, the rupture extending in an unbroken line for a distance of about 13ft., and then diverging in a transverse direction, and eventually separating the boiler into five or six pieces.

"The fragments of exploded boilers very frequently fly in opposite directions, but this was not the case in the present instance, the whole of them being thrown eastwards, some to the north-east, others to the south-east. This was no doubt due to the first rupture having taken place at the longitudinal seam just described, and at the west or chimney end of the boiler, so that it would heel up in position before all the rents were completed. Rapid as the development of the rents in a boiler may be on explosion, it is still not completely instantaneous, and in the short interval that elapses, the position of the shell, as a whole, becomes changed before the flight of the parts takes place, in consequence of which their normal direction is diverted, and the general results complicated.

"Each of the fragments in this instance was thrown a considerable distance from the original seating of the boiler, one about 130 yards, and another about 190 yards, while a ball weighing 57lb., and belonging to one of the floats, was thrown to a distance of 480 yards, or upwards of one-quarter of a mile. No. 3 boiler, which was on the right hand side of the one that exploded, and next to it, was lifted from its seat, blown against the engine-house, and flattened. It was not at work at the time, or another explosion must have resulted. No. 5 boiler, which was on the left-hand side of the one that exploded, and next to it, was also lifted from its seat, but not so roughly handled as No. 3, being merely rolled over No. 6, and thrown upon the ground. The fall made a hole in it, but fortunately, one not so large as an ordinary manhole, so that the rupture did not extend, and no explosion resulted, although the boiler was at work at the time, and the pressure of steam within it about 30lb. on the square inch.

"With regard to the cause of the explosion, it appears that the primary rent took place at the chimney end of the boiler, and at the longitudinal seam of rivets, previously referred to, which ran from one end of it to the other, a little below water-line, and on the right hand or north side. The water with which the boiler was fed was drawn from the limestone, which it was stated at the inquest was found to fur the boilers in three weeks, which must have proved very trying to those of the externally-fired class. It appears that the exploded one had originally been fired upon the right hand or north side, and that repairs at that part had been rendered necessary. Boilers are frequently injured by repairs, and it was just where these had been executed, and with plates of very brittle and inferior quality, that the primary rent occurred. In boilers plated longitudinally from end to end, as this one was, a hinge or buckling action frequently takes place at the overlap. This tendency is considerably augmented when boilers are not circular, and, in answer to inquiries, it was stated that this one had been three inches oval, so that the internal pressure would tend to change its shape every time the steam was raised or lowered. This action exercises a very fatiguing influence upon the plates, and is apt to crack them partially through from rivet hole to rivet hole; the cracks being entirely out of sight, since they occur under the overlap and between the two plates. The superintending mechanic at this colliery assured me that it was customary for them to detect these cracks on taking out old plates from their own boilers, and since the cracks in a plate could not be seen until the adjoining one was removed, it was frequently found that the removal of one plate led to that of a second, and sometimes to that of a third or even more. On examining the edge of the fractured plate at the part where the rupture had evidently commenced, there was every appearance of there having been an old crack penetrating nearly half way through the plate, and running longitudinally from rivet hole to rivet hole, just as those already described had done. I do not attribute this explosion, therefore, to shortness of water, or to excessive pressure of steam, of neither of which was there any evidence, but consider that it was due to the unreliable character of these externally-fired boilers, especially when, as in the present instance, they are plated longitudinally from end to end, not made truly circular, repaired with plates of inferior quality, and fed with sedimentary water.

"On the present occasion I have to report five explosions, from which nine persons have been killed, and seventeen others injured. Not one of these explosions, however, occurred to boilers under the charge of this Association, while the distance at which they have all taken place has precluded my making a personal investigation on the spot.

"TABULAR STATEMENT OF EXPLOSIONS,
From August 27th, 1864, to October 21st, 1864, inclusive.

Progressive No. for 1864.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
24	Aug. 29	Locomotive	1	1	2
25	Sept. 6	Ordinary single flue, or Cornish. Internally-fired	1	1	2
26	" 9	Ordinary double flue, or Lancashire Internally-fired	7	7	14
27	" 29	Particulars not yet ascertained.	0	1	1
28	" 30	Do. Do.	0	7	7
		Total	9	17	26

BROADSIDE *v.* TURRET SYSTEM.

We notice in the *Army and Navy Gazette* of the 26th ult. a letter, under the above title, from Capt. T. E. Symonds, R.N., the able and persistent advocate of the "twin screw" system, and whose practical inventions in conjunction with those of his late partner, Mr. R. Roberts, C.E., have so often been made prominent in our pages. The letter being so eminently practical, and bearing on questions of such vital importance, both as regards the efficiency and economy in the construction of war ships, we give it *in extenso.* And though Capt. Symonds's efforts have been ignored by the Admiralty, we confidently expect that in the independent and important position which he now holds as Chairman of the London Engineering and Iron Shipbuilding Company (Limited), he will have the power of effecting improvements on a more comprehensive scale than when trammelled by Government supervision and obstruction, and which we trust will result in benefit to the country, and also to the shareholders of the company:—

Sir,—Whilst fully according to Captain Coles all the merit so justly his due, and congratulating him on the success he has so far attained in the *Royal Sovereign,* as an advocate of the "broadside system," I cannot permit some of his remarks in the *Times* of the 12th instant to pass unnoticed. Although admitting that the recent trials have disposed of some of the prophecies against the success of this ship, I do not swerve from the opinions I have repeatedly expressed in my criticisms of the turret principle, especially as regards seagoing ships, which the experiments in the *Royal Sovereign* have in no way shaken. Taking Capt. Coles's first observation as to the "test the turret system has undergone in actual warfare," I would remind him that authentic public reports as well as private information from naval officers and others who have served in the American turret vessels, are decidedly unfavourable to that system, and there are several instances on record of vessels fitted on the broadside principle, when under the same fire, coming out of action comparatively scatheless, when those on the turret principle have been severely mauled. Take the *Ironsides,* for example, at Charleston, which was struck with from 60 to 70 shot, and sustained no material damage, the monitors having without an exception their turrets either totally crippled or badly injured. The recent affair at Mobile furnishes another striking example of the efficiency of the broadside ship. Captain Coles must bear in mind that, although the fitting of this ship's ports was admitted to be very imperfect, "she engaged the whole Federal fleet, consisting of 18 frigates and monitors, for an hour and a half, surrendering at last only when disabled in her rudder, and in danger of being run down by a combined movement of the Federal fleet." (Had this vessel been fitted with "twin screws," so as to have manœuvred with her shorter antagonists, and had her rudder been submerged, as is the case in that system, the result might have been very different.) The experience derived from this and other "tests in actual warfare," added to the total inefficiency of the American turret-vessels for coast purposes, has brought them into disfavour, so much so that the vessels now building are for the most part fitted with fixed turrets of block-houses. It may be argued on the one hand that their turrets were not properly constructed, but on the other it is said that neither powder nor guns are equal to those we are experimenting with; however, in the case of the *Rolfe Krake,* the Danish turret-ship, to which Captain Coles refers, and built, as it is stated, from his own designs, the former objection cannot hold good, yet when exposed to the fire of the Prussian 24-pr. battery (by some reported 12-pr.), as stated by a Danish officer who was in one of the turrets, "the shot did not penetrate, but in two instances when struck on its centre it was very much shaken." Now if these turrets, constructed on the most approved principle, were thus affected by such light ordnance, it is a just inference that those of the *Royal Sovereign* might fare even worse with the rough handling they would receive from 300, or even 100lb. shot. For this reason do I concur with those who recommend a turret similar to the *Royal Sovereign's* being tested under the same circumstances as those targets representing broadside plates. With regard to the "restricted power of training broadside guns," which Capt. Coles quotes, although it may apply to long ships propelled by the single screw, I consider that by adopting the twin screw system that objection vanishes. It has been proved beyond all question that fixed guns in the American vessels are pointed in the most accurate manner by the screws alone, and it is by such means that the heaviest guns on the broadside of a ship can be brought into any required line of bearing, the final adjustment being completed when necessary by simple mechanical means. I cannot for an instant admit that a gun of 15 tons, or even larger, cannot be fitted to the broadside of a ship so as to be moved and controlled with equal facility as a turret weighing 150 tons; to say that such a thing is impossible is a reflection on the mechanical skill of this country. The American gun-carriage presents a very fair example, which can no doubt be altered and improved by substituting wrought-iron framework for wood. Such improvements could be easily effected, and I see no reason why a gun should not be thus supported as well as a locomotive engine; and I look to the introduction of iron for gun-carriages to relieve us from many difficulties in their construction. I maintain that broadside guns of heavy calibre can be so manœuvred, and can be trained through a sufficient arc for all practical purposes, having moreover the advantage of firing at the top of the rolling motion, which the gun in the turret cannot, and being capable of an amount of depression unattainable in the turret system. The bevilling of the port-holes in the case I have described would not be required to the extent Captain Coles states. Nor do I see any difficulty in making the embrasures of the ports quite as strong as those of the turret, or of increasing the diameter of the fighting bolts, and fitting and protecting them so as to obviate the chances of injury which Captain Coles seems to apprehend. In fact, the ports in my twin screw ship are precisely similar to those of the turrets. A broadside ship has this advantage over the turret, viz., that if engaged for any length of time the turret guns would become heated, which would compel a cessation of fire, or if damaged, or should one of the turrets become fixed (by no means an improbable contingency, so far as we learn from practice), there would be a material and fatal diminution of her aggressive power; whereas, under similar conditions, the broadside gun-ship, if fitted with two screws, would readily bring the opposite guns into action with an unimpaired side, by turning the ship on her centre. Again, in fighting both sides, the broadside gun-ship would have an equal weight of metal on either side; whereas the turret-ship would have to divide her central guns, and under such circumstances be very inferior. I have always understood from Captain Coles's writing and statements that he claims the "bow attack" as his strong point, arguing that he can fire his foremast guns right ahead, and bring his guns to bear on any point without deviating from his course. Now is this so? Has it been proved in the *Royal Sovereign?* I contend that there are obstructions in that ship, although not a sea-going ship, which prevents his firing right ahead, and even at the angle he can fire them, not with sufficient depression. A recent attempt to depress the foremost guns in the *Royal Sovereign* resulted in blowing away a portion of the hawse pipes, which in that ship project above the deck. In the published plans of "sea-going turret-ships," the foremast, bowsprit, standing bulwarks, and many other fittings absolutely necessary on the forecastle of that class of vessel, would entirely preclude firing right ahead, and little or no depression could be given to the guns of the foremost turret hitherto shown; thus making it impossible to strike a vessel at close quarters right ahead without "yawing," which is the point Captain Coles and other advocates of the turret system so much depreeate in the broadside ship. "Last, though not least," as Capt. Coles justly observes, comes their fitness as a habitation for officers and crew. Although never pronouncing them uninhabitable for a time, I never did nor can I believe their accommodation and sanitary arrangements sufficient even for a guard-ship for any number of men during a long period, and it is of no use trying to disguise the fact, that no matter how favourable the reports may be of her other qualities, it is well known that the *Royal Sovereign* is for many reasons by no means a desirable residence, and I very much question whether the *Prince Albert* will not prove still less so. Now, sir, I think I may state, without fear of being considered egotistical, that I have laboured unremittingly to meet the objections raised to the broadside system as it now stands, and to produce either a coast defence or sea-going ship with broadside guns that shall possess all the qualities claimed for the turret system without sacrificing accommodation or general efficiency. I some time since submitted a plan for a sea-going broadside ship capable of firing four guns right ahead or astern (two from the main and two from the upper deck in each case) at any required angle of depression from behind armour-plates as heavy as Captain Coles's turret, *the ports being no larger than his;* in this ship there is no deviation from the normal construction, nor do I sacrifice any of her sea-going properties or accommodation, whether on deck or below, retaining, in fact, the frigate type. This plan is applicable to most existing iron ships. I undertake in this ship—whether under canvas or steam—to fire more guns on any given point without deviating from my course than Captain Coles can with any turret-ship he may design of the same tonnage and power. I furthermore undertake to cut down a ship of the *Royal Sovereign* type according to designs I have also submitted, and fit her with twelve of the same guns the *Royal Sovereign* now carries, three or even four of which shall fire right ahead, or astern, at an angle of depression unattainable in the *Royal Sovereign,* if the ship be intended for harbour defence alone; but if for coast defence with two guns ahead and two astern, the latter ship being capable of crossing the Channel in any weather that an iron-clad ship could go to sea. In both cases, anchor gear and all sanitary and other accommodation is in its proper place, viz., the upper deck; the lower deck being appropriated to its legitimate purpose, viz., the accommodation of the officers and crew, and, if necessary, a large number of troops. I say advisedly that I can undertake to produce two such ships at a cost which shall together not exceed that of the *Royal Sovereign,* and in less than half the time occupied between the commencement and first trial of that vessel. These ships shall be equal to or superior for all purposes to which the *Royal Sovereign* can be applied. In conclusion, I would add that I heartily concur in the opinion that Captain Coles has a

fair claim to having his system tried to the uttermost, on public as well as on personal grounds. I trust at the same time it will be admitted that I have made out an equally strong claim for the broadside system, more especially as fitted with twin screws, which supply all the advantages claimed for the turret, without its complications—the ship herself becoming the turn-table; and I earnestly hope that the two systems may be tried side by side, aud ton for ton, without favour or affection, so that some practical result may be obtained which will save vast expenditure, endless discussion, and establish the model on which the fleet of the future may be safely and expeditiously coustructed.—I am, &c.,

Thos. Edw. Symonds.

10, Adam-street, Adelphi, Nov. 17, 1864.

IMPROVEMENTS IN THE PERMANENT WAY OF RAILWAYS.

Amongst the recent Patents in connection with the Permanent Way of Railways, one of these deserving of notice is that of Mr. S. C. Hemming, of the firm of Messrs. Hemming, iron-building manufacturers &c., and which we here illustrate.

Mr. Hemming, instead of constructing railway sleepers of wood, or in any of the well-known shapes or forms, and instead of employing corrugated iron in the manner heretofore employed or combined with the other parts of the permanent way of railways, employs a sheet or piece of corrugated metal which is arched or curved upwards, the length of the arch being in the direction of the length of the rails (Figs. 1 and 2). Upon the crown of the arch thus formed, the chair for receiving and securing the rails is attached, and the under surface of the chairs is corrugated to suit the corrugations on the exterior surface of the curved sleeper plates, the two arches being placed transversely to the line of rails (Fig. 3).

The ends of the curved corrugated sleeper plates are received in and retained by pieces of angle iron forming "shoe pieces," which are in turn tied together by angle iron or other suitable connecting pieces.

The sleepers and their chairs thus combined are secured together by a tie rod, which, by preference, is introduced under the crown of each corrugated sleeper, such tie rod being secured to each corrugated sleeper by the holding down bolts of the chair, which are thus made to pass through and secure together the chair, sleeper, and rod, or bar, as shown in the accompanying woodcuts, Figs. 4 and 5.

It is sought by this invention to combine durability, portability, elasticity, and cheapness.

Fig. 1.

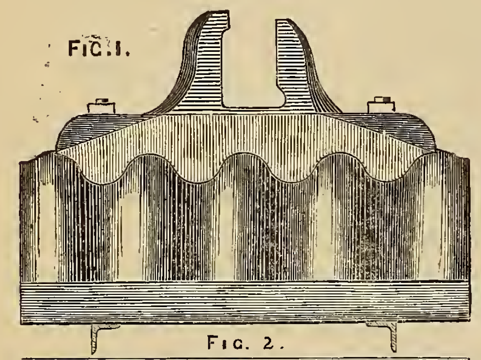


Fig. 2.

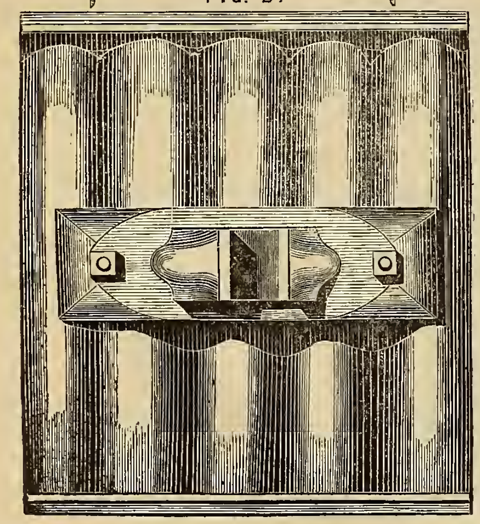


Fig. 3.

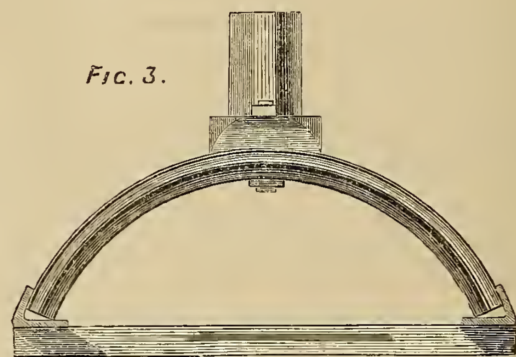


Fig. 4.

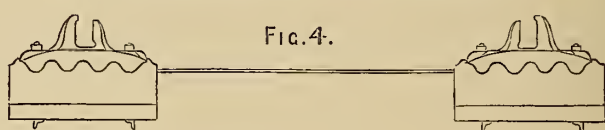
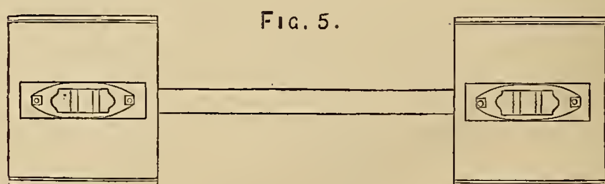


Fig. 5.



REVIEWS AND NOTICES OF NEW BOOKS.

La Stella d'Italia, &c.; per Luigi Borghi. (The *Stella d'Italia*, ironclad vessel of 20 guns, and 1,200 horse-power, original Italian project). Turin, Cotta & Capellino, 1864.

This pamphlet is a reprint of two letters published by Signor Borghi in the *Giornale della Marina* of October last. The author is of opinion that the superiority of the Italian navy, in point of *matériel*, as compared to those of Spain, and especially Austria, can be secured and maintained only by the construction of iron-plated vessels of larger size than those at present in use; he proposes ironclads of 100 metres (328ft.) in length, 17 metres (55ft. 9in.) beam, and 15 centimetres ($5\frac{1}{5}$in.) thickness of iron plate above the water line. For the other dimensions and details as proposed by Signor Borghi we refer the reader to the pamphlet under notice, which will also give a fair idea of the present state of the Italian navy.

Lighthouses. By David Stevenson, F.R.S.E., M. Inst., C.E., &c. Reprinted from "Good Words." Edinburgh: Adam and Charles Black. 1864.

The author has treated the important subject of lighthouses in his usual masterly manner, but has so rendered it as to make it of a popular character, adapted to the excellent periodical for which the articles were written, a task in which he has admirably succeeded; so that, as reprinted in the shape before us, it forms a book of 120 pages of very interesting and instructive reading, and in a very palatable form.

The book is got up in a manner very creditable to the publishers, the engravings interspersed throughout the book being very well executed.

BOOKS RECEIVED.

We have also received, amongst other books which have come to hand too late for notice in the present number, the two following:—

"The Story of the Life of George Stephenson, including a Memoir of his Son, Robert Stephenson." By SAMUEL SMILES, Author of "Industrial Biography," &c. London: John Murray. 1864.

"James Brindley and the Early Engineers." By SAMUEL SMILES, Author of "Self-Help," &c. Abridged from "Lives of the Engineers." 2 vols. London: John Murray. 1864.

CORRESPONDENCE.

We cannot hold ourselves responsible for the opinions of our Correspondents.

BOILER EXPLOSIONS.

To the Editor of THE ARTIZAN.

SIR,—Given, a boiler explosion; the boiler being well made, of good materials, capable of bearing a pressure of 70lbs. to the square inch, and containing a fair amount of water, so that it might be supposed the explosion can only be explained by a sudden, unaccountable increase of pressure. Given also, that the late Professor Daniell ascertained the heat of a common fire to be 1,141° F., and dull red heat, 980°; difference, 161°. Given, also, that an additional 25°, and no more, will increase the pressure from 70lbs. to 100lbs. (as may be seen in all good tables of temperatures and pressures), which, in certain cases, would burst the boiler, being an increase of 43 per cent. Thus it follows that even a small increase in the boiler heat might be important.

Now, the query is, to account for any increase of pressure at all; and the answer is, that even 25° account, in certain cases, for an increase of as much as 43 per cent. pressure, and they are only a fraction of the 161°, which might be, and probably often are, produced in two or three seconds by rapidly stirring the fire. It would be prudent, supposing these things to be so, for stokers to be cautious in stirring their fires.

Yours, &c., A CONSTANT READER.

NEW FLOATING BRIDGE AT PORTSMOUTH.

To the Editor of THE ARTIZAN.

SIR,—Referring to the answer in your last issue given to "P." upon the subject of the New Floating Bridge at Portsmouth, the following particulars as to the dimensions, &c., may interest your correspondent and other readers:—

Length of bridge, 100ft.; breadth, 59ft.; draft, about 3ft.; roadways on each side, and each 17ft. 6in. wide. The prows are of wood, and are raised and lowered by two small steam cylinders 7in. diameter and 8″ stroke. They can also be worked by hand when desired. The chains or cables by which the bridge is navigated are formed by 1⅝in. iron, the links being 10in. long and 5½in. broad; and the passage across (at high water) is about 700 yards, which can be done in 4 to 4½ minutes, but is generally performed in six minutes. The displacement at 3ft. draft is nearly 400 tons.

Engines.—Horizontal, having 27″ cylinders and 3ft. stroke; the air pump and condenser placed under the cylinders, the former worked from the piston and cross-bar, and is 10″ diameter and 3ft. stroke.

The multiple of the gearing that works the chain-wheel is 4½ to one, the latter making about seven turns per minute. The slide valves are of the piston kind, worked by double eccentric gear, and by which a good expansion figure is obtained.

Boilers.—Circular, 5ft. 10in. diameter, and 22ft. long, having tubes 8ft. long, 3½in. diameter outside; heating surface, 620ft.; the grate surface, 22½ft. There are two of these, one kept as a spare boiler; but one worked at a time. The consumption of fuel is about 16 cwt. per day of 14 hours (7 a.m. to 9 p.m.)

Yours, &c., ENGINEER.

THE ENGINES OF THE "DICTATOR."

To the Editor of THE ARTIZAN.

SIR,—I shall be glad if some of your English marine engineers and readers would express their opinion, through your journal, of the merits of the engines of the *Dictator*, as adapted more especially for the class of vessels on board which they are fitted, and as compared with the kinds of engines preferred in England.

The description of these engines is doubtless familiar to your readers, whom I would refer also to the *Scientific American* of the 12th inst., in which it is stated that—

"The simplicity of the design, the directness of the action, the entire absence of superfluous ornament and weight of metal, as well as the harmony in the vast proportions of the machines, strike the engineer at once. The cost of construction, which is usually very great in large engines, must have been much reduced in these, for there are no intricate castings, no joints, levers, or other parts which are not readily made in any ordinary machine shop.

"It is a great advantage in these engines that they can be repaired in ports where there are only the ordinary facilities. No costly and ponderous crank shafts are to be seen, but the rod of each engine connects directly to a driving wheel on a straight shaft.

"Neither are there any massive links for engineers to sweat and tug at in order to reverse the engines. A simple movement of the hand controls both of them with facility, and a boy ten years old could work them. They have been reversed from full ahead to full back in twenty seconds. Hydrostatic pressure moves the reverse gear as well as the cut-off valves, and the system is free from the objections which have hitherto attended this method of working reverse gear. Means are provided for working the engines by hand, if necessary. The engines sit athwart ships, and the valve gearing is in the centre. Everything is in plain sight, and from his post the engineer can see every pin and principal part at a glance."

Yours, &c., MARINE ENGINEER.

New York, November, 1864.

NOTICES TO CORRESPONDENTS.

MECHANIC (San Francisco).—Your interesting letter we are unable, through want of space, to insert in our present number, but we will arrange, if possible to give insertion to it in our next.

SUBSCRIBER.—We should recommend the formula:—

$$\delta = \cdot 00006388\, n\, d + \tfrac{1}{3}\text{in.}$$

for all cast iron pipes subject to a limited internal pressure (n being the number of lbs. per square inch, d the diameter). But we are afraid the pressure you indicate is so very excessive that the formula would lead to an extravagant dimension. You had better verify whether the pressure stated is meant for the aggregate area, or per square inch of the section of the cylinder.

C. R.—We think the formula (I.) to be correct in a general way, but not absolutely speaking. We can only say that various other elements, independently of those denoted by the co-efficients of the formula alluded to, may affect the resistance. As regards the work from which you quote formula (II.) we will draw your attention to the caution you will find given to "H. S.," Notices to Correspondents, in THE ARTIZAN of September last.

R. S. (Llanelly).—The ratio of the torsional strains is

Wrought iron : cast iron :: 3 : 7

for your purposes, *i.e.*, a torsional strain of 3 units of weight per unit of square measure will have the same effect on cast iron as 7 units of weight per unit of square mearsure on thin bars of wrought iron.

"TUBE."—Yes; you are correct. We have seen the article to which you refer and are not a little surprised at its appearance in such a journal, as giving an air of novelty to an invention which was noticed by us and other journals at considerable length, now nearly four years ago. We know nothing of the parties whose names appear in the article, as the alleged introducers of the pipes. The Mr. Samuel Hughes, C.E., whose name is given we *do* know as an engineer, whose writings and efforts in aid more especially of reform and economy in gas supply, have gained him a well-deserved professional reputation. It was he who conducted the experiments referred to at Westminster, now some four years since.

INDIA CIVIL SERVICE.—Yes; we *can* give you, through our pages, what you require. Our next issue will contain, as an example of the examination through which candidates for appointments in the engineer establishment have to pass, a list of the several questions, &c., required to be answered at the last competitive examination in June of the present year.

Errata.—In our last issue, in Professor Rankine's Paper on "Stream Lines," equation 8, for

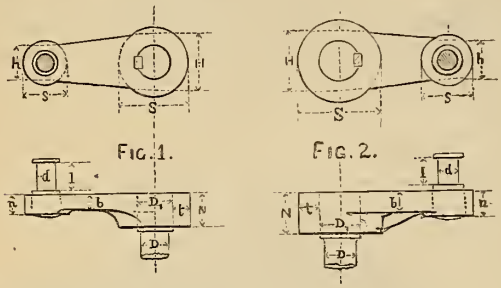
$$u \frac{d^2 u}{d x^2} + \frac{d u^2}{d y^2} + \frac{d u^2}{d z^2} = 0,$$

read

$$u \frac{d^2 u}{d x^2} + 2 \frac{d u^2}{d y^2} + 2 \frac{d u^2}{d z^2} = 0.$$

G. H. (Bosphorus).—Remittance, 13*s*., received.

W. E. B.—We cannot go into all the details of your calculation, but will suggest the following proportions.—In the annexed illustration fig. 1 shows a wrought iron crank, fig. 2 a cast iron crank with corresponding shaft; the letters denote identical parts in both.



If we call

P the torsional power in lbs.,
D the diameter of the shaft,
v the speed in feet,
n the number of revolutions per minute,

we have for cast iron shafts with slow motion

$$D = 0{\cdot}707 \sqrt[3]{\frac{P v}{n}} = 5{\cdot}47 \sqrt[3]{\frac{HP}{n}} \text{ inches,}$$

idem with quick motion

$$D = 1{\cdot}047 \sqrt[3]{\frac{P v}{n}} = 8{\cdot}2 \sqrt[3]{\frac{HP}{n}} \text{ inches.}$$

For wrought iron shafts take $\frac{1}{8}$ less, *i.e.*, respectively

$$D = 4{\cdot}79 \sqrt[3]{\frac{HP}{n}} \text{ and } 7{\cdot}175 \sqrt[3]{\frac{HP}{n}}$$

The diameter D being ascertained, we take both for wrought and cast iron cranks and shafts

$$D_1 = 1{\cdot}2 \text{ D}.$$

Supposing R to be the radius of the crank, $\omega = b : H$ = proportion between thickness and width of crank, we have for both materials

$$H = 8{\cdot}2 \sqrt[3]{\frac{HP}{\omega n}}$$

he length of the nave we take in both cases

$$N = 1{\cdot}2 \text{ D}$$

and its thickness respectively

$$\left.\begin{array}{l} t = 0{\cdot}425 \text{ D} \\ S = 2{\cdot}05 \text{ D} \end{array}\right\} \text{for cast iron shaft and wrought iron crank,}$$

$$\text{and } \left.\begin{array}{l} t = 0{\cdot}50 \text{ D} \\ S = 2{\cdot}2 \text{ D} \end{array}\right\} \text{if both crank and shaft consist of the same material.}$$

The diameter of the axle respectively

$$d = 0{\cdot}9 \text{ D} \sqrt[3]{\frac{D}{R}} \text{ for cast iron shafts,}$$

$$d = 1{\cdot}1 \text{ D} \sqrt[3]{\frac{D}{R}} \text{ for wrought iron shafts.}$$

$$\text{The length } \left.\begin{array}{l} l = 1{\cdot}25\, d \\ n = 1{\cdot}3\, d \end{array}\right\} \text{in both cases,}$$

$s = 2{\cdot}2\, d \quad h = 1{\cdot}3\, d$ for wrought iron cranks,
$s = 2{\cdot}4\, d \quad h = 1{\cdot}5\, d$ for cast iron cranks.

We think these data will suffice for your purposes.

P.—In answer to your further inquiry, we are glad to be able to give you some additional particulars in connection with the New Floating Bridge at Portsmouth, as by the courtesy of one of our oldest subscribers, and a frequent correspondent upon subjects of engineering interest, we are enabled to state, with reference to the design, that the directors of the bridge company nominated Mr. F. H. Trevethick (son of the Trevethick of Cornish engine memory) as their engineer, and in that capacity he reported upon the different schemes proposed, recommending generally that of Messrs. James Watt and Co.; but we believe Mr. Trevethick was desirous of having engines of his own design adopted, although he gave way upon this, allowing the engine and boiler arrangements of Messrs. James Watt and Co. to be adopted; as also the design of the bridge generally, excepting some modifications as to the cabins, the position of the gasholder, &c. Mr. Trevethick, also, was entrusted, we understand, with the preparation of the working drawings which were executed by him, with the aid of his assistant, Mr. Tijon.

RECENT LEGAL DECISIONS
AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

Under this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

Liability as Contributories.—The Lord Chancellor decided, *in re* Mosely Green Coal and Coke Company, that if a person has consented that his name be entered as a shareholder in a company in respect of shares not fully paid-up, though on a contract, known to the directors, that he shall incur no liability, he remains liable as a contributory until his shares are legally transferred; and if before such transfer the company be wound-up, he must be placed on the list of contributories, and has no right to require the share register to be amended by substituting the name of the true owner.

Rating Railways.—The Midland Railway Company *v.* The Overseers of the Parish of Bedgeworth, Gloucestershire.—This was a question (Court of Queen's Bench, Westminster) as to the validity of a poor rate upon a portion of the Great Western Railway within the parish, over which the Midland had by special agreement "running powers;" and the point was whether in such a case the company having power to run trains on the line of another company can be deemed to be in beneficial occupation, so as to be rateable for relief of the poor. There is a special agreement between the two companies under which each has power to run trains over the line of the other; each company has exclusive powers, as proprietors, over its own line. The parish authorities had rated the Midland Company in respect of the profits of that portion of the Great Western line which they used, and which was within the parish. The Midland Company appealed, and hence the present appeal. The Court decided in favour of the Midland Railway Company and against the rate, on the ground that they had no occupation of the line which was rateable.

The Staffordshire and Worcestershire Canal Company *v.* the Birmingham Canal Company.—This suit was instituted for an injunction to restrain the defendants from depriving the plaintiffs, either by diversion or pumping or otherwise, of any part of the water which at present is passed by means of the Wolverhampton Locks from the Wolverhampton level of the defendants' canal at Autherley junction. By an Act passed in 1769, the plaintiffs were authorised to construct a canal from the Severn, between Bewdley and Titton Brook, in Worcestershire, to cross the Trent at or near Hayford-mill, in Staffordshire, and to communicate with a canal intended to be made between the Trent and the Mersey. By an Act passed in 1769, the defendants were incorporated; and they were thereby authorised to make a canal from Birmingham to Autherley, near Wolverhampton, and there to join the plaintiffs' canal. At that point, however, the two canals were on different levels, the level of the defendants' canal being about 132ft. above that of the plaintiffs'. They, therefore, communicated with each other by means of a series of locks, extending over a space of about 3,200 yards, which were originally 20 in number, but in 1791 were made, and now were, 21 in number. These were called the Wolverhampton Locks, and by their means the plaintiffs had, since 1791, received water into their canal from the defendants' canal, whenever a boat passed from the defendants' canal into the plaintiffs' canal. Owing to the late dry weather the defendants had suffered great inconvenience from a scarcity of water, and in order to save the loss of water which took place in the last lock communicating with the plaintiffs' canal, they proposed to allow that lock of water to pass by means of a sluice at the side of their canal into a reservoir, from which it is to be pumped back into their canal, and they accordingly gave notice to that effect to the plaintiffs. This suit was instituted to prevent the defendants from carrying out the plan indicated in that notice. The Vice-Chancellor said that under a legislative authority the plaintiffs had enjoyed for a public purpose for more than 70 years what the defendants now proposed to deprive them of, and he saw no ground for the view that the case was not within the law of prescription as settled by Act of Parliament. It therefore seemed to him that the defendants had no right to pump back into their canal the water from the last lock at the Autherley Junction. There must, therefore, be a perpetual injunction in the terms stated above. The costs would follow the result.

Cubitt *v.* Smith.—This was a suit instituted for the specific performance of a contract dated the 7th day of April, 1859, whereby the plaintiff agreed to demise to the defendant a piece of land on the south-east side of the Pimlico-road and south-west side of St. George's-road, together with a house to be erected thereon, for 66 years, at a rent of £70 per annum; and the defendant agreed that he would within eighteen months from the date of the agreement build a house on the land of the value of £700 at the least, of not less than three stories high above the basement; according to an elevation section plan and specification to be previously approved in writing by the plaintiffs, and according to the Act or Acts of Parliament. Soon after the execution of the agreement the defendant entered into possession of the land, and plans of the proposed house were prepared by him, and approved by the plaintiffs. According to those plans, the distance from the wall at the back of the house to the frontage of it in the Pimlico-road was to be 169ft., and upon that assumption the defendant expended a sum of £400 on the premises. It was afterwards ascertained that the Board of Works objected to the completion of the house according to the original elevation, and required the frontage towards the Pimlico-road to be put back 3ft., so as to be on a level with that of the adjoining houses. The defendant then ceased to build on the land, and the house was now unfinished. Hence the present suit. His Honour was of opinion that the contract was perfectly clear in its terms, and one which this Court would enforce. It was plain that the house was agreed to be built according to the provisions of the Acts of

Parliament regulating the building of houses in the metropolis; and that agreement and the plans were equally binding on both the plaintiffs and the defendant. By some inadvertence on the part of both parties the site was marked out in the plans in such a way as to contravene the rules of the Board of Works, but there was nothing in the case to show that the plans could not be in that respect modified. His Honour thought the defendant was bound to go on with the house accordingly, and made a decree for specific performance of the agreement, with costs.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

Rouen Art-Union.—In the year 1834 a society was formed, with the title of "La Société des Amis des Arts," "to aid the progress of art in Rouen, and to encourage artists by the purchase of works from the exhibitions organised by the municipal administration." The condition of membership is the payment of 30 francs on the occasion of each exhibition, and subscribers pay 10 francs each, the pictures purchased being distributed by lottery amongst both classes, every 10 francs carrying the right to a chance. For some years the exhibitions were annual, but at present they take place every second year, and, since the establishment of the society, it has purchased and distributed nearly a thousand pictures, at a cost of upwards of 180,000 francs. The exhibitions are held in the Hôtel de Ville, and the municipality votes a sum of money to cover the expenses, and another in aid of the funds of the society, or for the purchase of works of art for its own public gallery. The number of works of art in the Exhibition now open is 819, and many of those are by well-known artists.

Exhibition in Copenhagen.—A committee appointed to inquire as to a general exhibition of the manufactures and works of art of all the Scandinavian states, in Copenhagen, has just published a report, in which it is proposed "that an exhibition of the products of the three Scandinavian states—Sweden, Norway, and Denmark—should take place in the summer of 1866, and that for that purpose a crystal palace should be constructed at the expense of the state and of the capital."

Atmospheric Hammer.—An improved and very compact atmospheric hammer, the reservoir of which is used as a blower when the hammer is at rest, has been patented by Mr. W. D. Grimsbaw, of Mitcham. He constructs the framework of the machine hollow and air-tight, so that it may be employed as a reservoir of the compressed air, and at the back part of the bed plate he bolts or fixes a double air-pump, driven by a belt or by gearing. The piston of the said air-pump may be worked by a crank or other suitable contrivance. By the action of the air-pump he surcharges the hollow chambers in the framework of the machine with compressed air, which may be rarefied or not at pleasure. The hammer head is fitted on a piston rod working into an inverted cylinder, with similar arrangements to an ordinary steam cylinder, excepting in the construction of the cut-off, the valve of which has two additional port-holes, which gives the workman complete control over the hammer, and enables him to regulate the blow at pleasure. The hammer is constructed upon a compound bed plate, therefore may be moved backward and forward, and is capable of striking any required blow upon any particular part of the anvil, or on a series of anvils, or of plating or bending heavy work, and performing such work as it has not been practicable for previously constructed mechanical hammers to execute. When the hammer is at rest the pump and air chambers may be employed as a blast or blower for the furnace, with considerable advantage and economy. The blast may be used hot or cold, as may be required. The hammer is entirely under the control of the workman, both as to speed and the power of the blow. The speed may be varied from 1 to 500 blows per minute, and its striking force from one to two thousand pounds; or in accordance with the constructed power of the machine, it will do its work with considerably less consumption of power than is usually employed by steam-hammers.

Improved Crushing Machinery.—The improvements in crushing machinery patented by Mr. Hoffman consist in the employment of two segmental-shaped beams, in the faces of which the patentee lets in steel or other hard metal crushing blocks; between these beams he places a roller, and lets in similar blocks on two opposite faces thereof. He connects the roller by jointed rods to a crank, and communicates a rocking motion to the roller. Upon the wearing of any of the crushing blocks they can be removed, and other blocks may be substituted for them; or he makes use of two rollers, or two segmental-shaped beams only.

The Fall of a Chimney-stack, recently erected at the chemical works of Messrs. Allhusen and Co. (the Tyne Chemical Works), at Gateshead, recently took place, but without injury to anybody. The chimney was partly erected about twelve months since, when it was left to settle, so as to gain solidity and strength, and when it was thought the structure was sufficiently firm the builders began to complete it. Its height was 240ft. The whole height of the chimney-stack being completed, it began to exhibit signs of weakness; and, from the force of the wind, perhaps, leaned considerably from the perpendicular. The workmen were ordered to raise a scaffold on the inside, that it might be taken down: a railing was placed around it; and the road which passes by was stopped, to preclude any possibility of a mishap. The workmen had barely reached the top of the scaffolding, when they became alarmed and left the place; and soon after the upper half of the chimney, or about 100ft., fell into the road. The recent heavy rains are blamed for keeping soft the mortar or cement used in the erection.

The Patent Stone Bricks.—At a recent meeting of the South Wales Institute of Engineers, Capt. J. J. Bodmer read a paper "On the Nature and Manufacture of Patent Stone Bricks." The writer described the process adopted by Messrs. Bodmer, Brothers, Newport, in the manufacture of the patent stone bricks. When they considered that labour was now about 100 per cent. higher than it was about eighty years since, anything which tended to lower the price of so useful and general a commodity as bricks, must be considered a timely invention. The stone bricks, he said, had fulfilled these requisites. Another very great advantage which these stone bricks had over the common bricks was, that they improved by age; whereas the common bricks skinned and deteriorated. Some of the bricks were exhibited to the members. Some had been made of Aberthawe lime and sand; others of sand and cinders; and some others had been made out of slags, which were particularly hard and durable. Some of the bricks made by the patent process were stated to have borne a weight of three tons per brick, after having been made but fourteen days; others, which had been longer made, were capable of bearing about thirty tons per brick. The chief difficulty in the manufacture was that of reducing the material employed to the fineness of sand, or, better, to that of powder.

Preserving Flowers.—Mr. C. R. Tichborne states that, being desirous of preserving a vegetable *lusus naturæ* for some time, he submerged it in some weak glycerine, considering that that fluid would be less likely to destroy the tender organism, and also remembering that it had been found most efficient in the preservation of animal tissues. The glycerine answered its purpose most admirably, preserving the delicate parts of the plant and preventing decomposition. He immediately saw that this property of glycerine might be made available for certain pharmaceutical purposes, where it was desired to preserve or extract the aromata of vegetable products, such as elder, orange, or rose flowers, and also might be substituted for the oils and fats used in the purest process termed enfleurage. The glycerine need not be especially pure, but should be devoid of odour. The elder-flowers should be gathered when the corolla is fully expanded, but not too far gone; they should then be plucked from the stem, and packed firmly in wide-mouthed bottles or jars, without crushing them; and the whole should then be covered with glycerine. Mr. Tichborne states that he has thus preserved flowers for two years, and, on distilling them, procured a water the perfume of which has equalled the most recent product. For the preservation of the aroma of the flowers he considers the employment of glycerine far superior to the system termed enfleurage, in which heat is used.

Sunshine.—A curious return is regularly obtained in Scotland from above 50 stations of the Meteorological Society—a return of the number of hours of sunshine. Taking the mean of all these stations, the number of hours of sunshine in the last seven years has been as follows:—In 1857, 1,665; in 1858, 1,825; in 1859, 1,817; in 1860, 1,620; in 1861, 1,674; in 1862, 1,568; in 1863, 1,711. The number in 1858 averaged exactly five hours a day throughout the year. In the six months from April to September, the summer half of the year, there were 1,154 hours of sunshine in 1857, 1,261 in 1858, 1,302 in 1859, 1,083 in 1860, 1,094 in 1861, 1,052 in 1862, 1,135 in 1863, 1,239 in 1864. The number in 1858 averaged very nearly seven hours a day in these six months. In the eight years, 1857-64, the sunniest month was May in three instances, June in three, July in two.

The London Coal Trade.—During the month of October the tonnage of coal entered in the port of London by sea, railway, and canal reached 442,100 tons, 9 cwt., against 503,105 tons, 4 cwt. for the corresponding month of October, 1863. This great decline is apparent only upon the seaborne tonnage, which has declined from 309,614 tons in October, 1863, to 210,421 tons in 1864. From Newcastle 180 ships arrived, bringing 97,584 tons; from Seaham, 28 ships and 6,385 tons; from Sunderland, 138 ships and 62,017 tons; from Middlesborough, 16 ships and 5,030 tons; from Hartlepool and West Hartlepool, 96 ships and 27,847 tons; from Blyth, 2 ships and 476 tons; from Scotland, 10 ships and 812 tons; from Wales, 18 ships and 4,823 tons; from Yorkshire, 20 ships and 2,585 tons; 1,770 tons of small coal in three ships, and 1,092 tons of cinders. The railways brought 230,928 tons, 9 cwt., against 192,859 tons, 14 cwt., in October, 1863; of this the Great Northern coal traffic was returned at 94,277 tons; London and North-Western, 88,551 tons, 5 cwt.; Great Western, 17,603 tons; Great Eastern, 14,287 tons, 8 cwt.; Midland, 2,219 tons, 1 cwt., to King's-cross, and 9,820, 14 cwt., to St. Pancras Depot; South-Eastern, 2,022 tons, 15 cwt.; South-Western, 1,670 tons, 6 cwt.; London, Chatham, and Dover, 430 tons; and Tilbury and Southend, 48 tons. The canal traffic for the month was 750 tons, 10 cwt., against 631 tons, 10 cwt., for October, 1863. For the ten months ending the 31st of October the railways brought to London 1,900,278 tons, 3 cwt., against 1,430,013 tons, 12 cwt. for the same period of last year, being an increase of 470,264 tons 11 cwt. The canal supply for the same period was 7,742 tons, 15 cwt., against 8,101 tons, 15 cwt., for 1863, being a decline of 359 tons. For the first ten months of the present year 2,562,454 tons of coal, &c., came by sea in 6,879 ships, against 2,692,908 tons in 7,964 ships for the same period of 1863, or a decline of 1,085 ships and 130,454 tons. The total supply from all sources from the 1st of January to the 31st of October of the present year was 4,470,474 tons, 18 cwt., being an increase of 340,451 tons, 11 cwt., over the same period of last year, when the tonnage was 4,130,023 tons, 7 cwt.

Property Insured.—The estimated value of property insured from fire last year was £1,106,450,000—the amount of duty paid £1,050,679, a fraction more than 1*s.* 10¾d. per cent.

Alcohol from Coal Gas.—Berthelot, in his new work comprising the whole of his lectures on Organic Synthesis, delivered at the College of France during the present year, has demolished the proposition for making alcohol from coal gas, showing that the process is extremely costly, and the resulting spirit extremely impure.

Hardening Cast Iron.—A patent has been taken out for a new method of hardening the surface of castings. When the piece is filed up, or otherwise finished, it is brought to a cherry red heat, and then immersed till quite cold in a solution composed of 1,080 grammes of sulphuric acid, and 65 grammes of nitric acid to 10 litres of water. It is added that the thickness of the stratum hardened is sufficient for all ordinary purposes and that the iron suffers no distortion.

Storing Explosive Materials.—A very interesting operation, which attracted a great number of spectators, has been performed recently at St. Ouen, near Paris. A large floating dock on a new construction—210ft. long, 36ft. wide, and 18ft. high—was launched on the canal. This great iron boat, or floating dock, is intended for a store to hold all description of spirits, oils, or other inflammable liquids. These substances which are so frequently the cause of disastrous fires on land, are now to be secured on water, where they will be comparatively safe from fire. Each of the 100 compartments into which the iron boat is divided is sufficient to contain 250 hectolitres. Ten similar floating warehouses are to be built for the company of the docks of St. Ouen, of which five are already on the stocks. The iron boat was launched sideways into the canal of St. Ouen. After having glided along the slides placed under it, the iron mass, once in the water, moved forward more than forty yards by the force of impulsion. The operation was performed with complete success.

A Metropolitan Hydraulic Power Company.—A scheme for the supply of London with water at high pressure, for mechanical and other purposes, and for use in fires, is to be submitted to Parliament in the ensuing session, when application is to be made for an Act to incorporate a company with power to open the streets, &c., and erect machinery and apparatus for the supply of hydraulic power.

Throwing Mud in the Thames.—The Southwark and Vauxhall Waterworks Company have been fined, at the Wandsworth Police-court, in the sum of £20, for throwing

or slushing what is estimated as 100 tons of mud into the river at Battersea; a practice whereby the company are said to save £600 a-year in the cleansing out of their reservoirs!

NAVAL ENGINEERING.

Coppering Iron Ships.—A mode of coppering iron ships, so as to secure freedom from galvanic action, and at the same time attach the sheathing firmly, has been invented by Capt. Warren, and is at present in use at the works of Messrs. Brown and Simpson, iron shipbuilders, of Dundee. The bottom of the ship to be coppered must be first thoroughly cleaned, and when dry coated all over with Hay's varnish, which must be applied whilst hot. The bottom of the iron ship is then covered with the insulating material used by Capt. Warren, which is a kind of felt of about a fourth of an inch in thickness, and the edges of the layers of this material are lapped over each other for a couple of inches, to insure perfect insulation of the iron. The felt is put on by means of marine glue on it and on the shop's bottom, and pressed hard home—the process presenting little mechanical difficulty. After the ship's bottom has been covered, the outside of the felt or insulator is coated with marine glue upon the parts which are to receive the copper. The copper, which must be previously coated with varnish, is then placed upon the glued felt, the edges of each sheet and layer overlapping the others, the same as in the case of wooden ships. Along these edges nail-holes have been driven for small-nails to rivet them together—for though the copper sticks quite strongly enough to the felt, the edges which overlay each other are the better for being thus rivetted. The nails for this purpose are very ingeniously contrived, the points of each being spilt and slightly turned out, so that when they have passed through the two sheets of copper they came in contact with the insulator, and are opened out—thus forming, as Captain Warren says, a perfect clench. The effect of the water wash at the part of the side where the copper leaves off has also been provided against by Capt. Warren, who carries right round the vessel a batten or beam, on which the upper edge of the copper is fastened, but which is bevelled in towards the ship's side at its downward edge, so as to twist the copper violently.

The Royal School of Naval Architecture and Marine Engineering has been formally opened with an address by Mr. C. W. Merrifield, F.R.S., the Principal. He explained that the task which the Lords of the Admiralty and the Committee of Council had in view was somewhat different from that which presented itself in the Schools of Naval Architecture established on the continent of Europe. The difference mainly consisted in the fact that they possessed a system of secondary state schools, which did not enter into the plan of English education. The most striking contrast he could offer was the French system. They possessed an excellent school of naval architecture of very old standing, but it was simply a school of application. All the teaching on the Continent had a direct technical purpose, but that would not be the purpose of the present school. It has been announced that the subjects of the competitive examination, with the number of marks attached to each, will be as follows:—Pure mathematics, including arithmetic, geometry (plane and descriptive), trigonometry, and the elements of the differential and integral calculus, 2,500 marks; theoretical mechanics or applied mathematics, 1,000; practical mechanics, 750; practical shipbuilding, 2,000; steam, 750; physics, 500; chemistry, 500; mechanical and freehand drawing, 750. The competition in the present year will take place before Christmas.

Gunpowder—Regulations for Carriage of.—The following regulations to be observed by masters in charge of barges, &c., in the Thames, Medway, and Orwell, and canals adjoining, have been just issued at Woolwich by order of the Naval Director-General of Stores, Capt. Caffin, C.B., A.D.C. to Her Majesty. They set forth that—"Whenever barges or other craft belonging to, or engaged by, the Military Store Department are employed in conveying gunpowder, ammunition, or other combustible stores, the following rules are to be observed. With regard to fires or lights on board:—1. No fires are to be lighted on board any barge or craft conveying gunpowder or other combustible stores to any place in the River Thames within one mile below Gravesend or in either of the canals leading to Aldershot or Weedon; nor between the Nore and Chatham in the River Medway; nor within two miles of the Spit or outer buoy leading to Harwich harbour. 2. When the barge or other craft is one mile below Gravesend, and not nearer than half a mile of any inhabited place or magazine, fires may be lighted on board for cooking purposes only. 3. No barge having powder on board is to remain alongside the jetty or wharf of any magazine during the night, nor at any time (day or night) except when actually employed in the operation of embarking or disembarking powder or ammunition, but is to haul off and anchor at a distance of not less than 900 yards from such jetty or wharf if powder is on board, and if empty, of not less than 400 yards. 4. No barge having powder on board is to be left without a responsible watchman in charge. 5. With regard to the sailing and riding lights required to be carried according to the Admiralty regulations, the usual tinder-box, &c., will be used for the purpose of striking a light, and under no pretence are lucifer matches to be on board. Smoking on board is most strictly prohibited. 6. As soon as the barges, &c., have been loaded, the hatches are to be carefully covered with tarpaulins and battened down, and are not to be removed or disturbed until the cargo is ready to be discharged. 7. A powder flag must be kept flying during the time the combustible stores are on board."

The "Victoria," wooden three-decker, 121 guns, Capt. James J. Goodenough, made her official trial of speed at the measured mile in Stokes Bay, near Portsmouth, on the 21st ult. Her draught of water was 24ft. 7in. forward, and 27ft. 10in. aft. With four runs at the mile, with full boiler-power, she averaged a speed of 12·271 knots, and with two runs at half-boiler power she averaged a speed of 9·688 knots. This rate of speed is no great accomplishment, considering that the ship is driven by engines of 1,000-horse power, nominal, on the most approved and modern patterns, from the eminent firm of Maudslay and Field. The screw of the ship is on the Maudslay-Griffiths principle, with a pitch of 20ft. and a diameter of 26ft. 8in. The machinery and boilers gave the greatest satisfaction. The *Victoria* is intended as flagship for the Mediterranean station.

The "Warrior," iron frigate, was paid out of commission at Portsmouth on the 22nd ult. On the 21st ult. the frigate was officially inspected in every part by Admiral Sir Michael Seymour, G.C.B., Port Admiral and Naval Commander-in-Chief at Portsmouth. The ship was dismantled to her lower masts, and cleared out entirely, with the exception of her engines and boilers, &c. On the upper deck of the frigate he was engaged for some time with Captain Cochrane examining the positions of the masts, and discussing the advantage of the present system of rig adopted in iron ships of such length as the *Warrior* and *Black Prince*. The *Warrior*, when rigged, has no less a weight than 200 tons aloft at one time in masts, yards, sails, and rigging. With the exception of her lower masts, she presents a clear view above her bulwarks, and also a clear view of the spacious upper deck from her taffrail to her head-rail. From the upper deck Sir Michael Seymour descended to the main or gun deck, where he first made a minute inspection of a series of drawings and plans which have been prepared during the time the ship has been in commission, and which will be left as a legacy with the ship by her present captain for the benefit of those who may next command and serve in her. From the captain's cabin Sir Michael next proceeded round the main deck, inspecting the arrangements of the messes and the general fittings of the deck, including the capstans and the working of the chain cables, &c. The upper and main decks of the frigate, the parts in daylight and above the water-line, were certainly marvels of cleanliness. The engines lay fully exposed to view in every part, with cylinder covers off, crank shafts detached, crank and trunk bearings exposed, with slides, plummer blocks, &c., and all air-pump covers, valves, and cocks exposed, auxiliary engines being all dissected, &c. The condition of the different bearings and facings was surprising. One hundred and ten doors had been unscrewed from the faces of the boilers, and a view thus given fore and aft of the tops of the furnaces, tubes, and tube-plates; and nothing could be more satisfactory, considering the work the boilers have done during the three years and four months of the ship's commission. The most minute inspection cannot discover a fault in any part of the ship's hull; the frame and plating is as rigid as ever, and not a single instance exists 'tween decks or below of a bit of iron having given the hundredth part of an inch. This could not be more satisfactorily proved than with the ship's stern-post, which has to bear a thrust of fifty-six tons from the screw-shaft to propel the ship when she is under full steam, and which is now as immovable as it was on the day steam was first got up in the ship's boilers. The following has been the work of the ship:—Number of days steam has been up (under steam alone), 60; number of miles run when under steam alone, 7,810; total quantity of coal burnt (in tons) under steam alone, 3,132; total number of days steam has been up, 137; total number of miles ran under steam and sail combined, 8,434; total quantity of coals burnt, 3,018; total number of miles run under sail alone, 4,674—total number of miles run during commission, 20,918.

The Spanish Navy.—The Compagnie des Forges et Chantiers de la Seyne, in France, has just built a plated frigate called the *Numanchia*, for the Spanish Government, and a scientific commission nominated by that Government has, after assisting in her trial trips, which took place in the neighbourhood of Toulon, formally accepted the vessel. The frigate has cost nearly £320,000, and is said to be a fine specimen of iron architecture. The Spanish Government, in the event of war with Peru, intends, *on dit*, sending her to the Peruvian waters.

The Lords of the Admiralty have entered into a contract with Messrs. Castle and Beech, of Baltic-wharf, Millbank, for that firm to break up the whole of the steamers and sailing vessels ordered to be sold out of the navy from their unfitness for further service, the contract price to be paid to the Admiralty being 8s. per ton for the materials and timber, the sum of £15 per cent. on the gross sum paid by the contractors being allowed by the Government for all the metal returned to the Admiralty. The following is a complete list of the steamers and sailing vessels the order for the breaking up of which has been received at Chatham Dockyard:—viz., the floating battery *Trusty*, 14, 1,539 tons, 150 horse-power; the paddlewheel steamer *Dragon*, 6, 1,270 tons, 560 horse-power; the paddlewheel steamer *Firebrand*, 6, 1,190 tons, 410 horse-power; the paddlewheel steamer *Gorgon*, 6, 1,111 tons, 320 horse-power; the paddle-wheel steamer *Scourge*, 6, 1,124 tons, 420 horse-power; the screw gunvessel *Flying Fish*, 6, 871 tons, 350 horse-power; the paddlewheel steamer *Hermes*, 6, 850 tons, 220 horse-power; the paddlewheel steamer *Hecate*, 6, 817 tons, 240 horse-power; the paddlewheel steamer *Ardent*, 3, 801 tons, 200 horse-power; the screw steamer *Alacrity*, 4, 675 tons, 200 horse-power; the *Banshee*, 2, 672 tons, 350 horse-power; the *Roebuck*, 6,865 tons, 175 horse-power, screw gun vessel; the *Renard*, 4, 980 tons, 200 horse-power; the *Wrangler*, 4, 477 tons, 80 horse-power, screw gun vessel; and the paddlewheel steamer *Kite*, 3, 300 tons, 170 horse-power; together with the following sailing vessels, viz., the *Venus*, 1,069 tons; the *Daphne*, 726 tons; the *Frolic*, 509 tons; the *Fantome*, 483 tons; and the *Daring*, 423 tons.

Naval Appointments.—The following appointments have taken place since our last: F. W. Sutton (b), promoted to be Chief Engineer; J. Marwood, Engineer, to the *Dauntless*, for the tender; W. H. Hooper, Engineer, to the *Indus*, as supernumerary; H. H. Nethersole, Engineers, to the *Fervent*; E. Miles, in the *Asia*, promoted to be Engineer; F. F. Pendleton, in the *Styx*, promoted to Acting Engineer; E. Walters, Assist.-Engineer, to the *Formidable*, for the *Lizard*; W. Buchan, Chief Engineer, to the *Asia*, for the *Warrior*, when paid off; J. Simons, promoted to Acting Engineer for temporary service; W. E. Blackburn, Assist.-Engineer, to the *Hector*; J. G. Punnett, Assist.-Engineer, to the *Asia*, for the *Warrior*; W. G. M'Burney, confirmed as Second-class Assist.-Engineer; A. Marshall and J. M. Murphy, Engineers, to the *Espoir*; D. Park, Assist.-Engineer, to the *Espoir*; D. Ferguson, Assist.-Engineer, to the *Donegal*; D. Robb, Chief Engineer, to the *Fisgard*, for the *Oberon*; T. Traill, Chief Engineer, to the *Cumberland*, for the *Serpent*; W. Eames, Chief Engineer, to the *Victoria*; S. T. Wallis, of the *Irresistible*, W. J. Foster, of the *Pelican*, C. Mabherley, of the *Asia*, R. Dixon, of the *Blenheim*, and W. Fenton (a), of the *Brisk*, promoted to be Engineers; J. Patterson, of the *Rapid*, and A. Moreton, of the *Penguin*, promoted to Acting Engineers; J. Wood, of the *Frederick William*, promoted to be First-class Assist.-Engineer; F. H. Hermann, Engineer, to the *Asia*; C. Mabherley, Engineer, to the *Victoria*; F. Bush, Engineer, to the *Cumberland*, for the *Torch*; A. Hindmarsh, C. Salmon, M. Whyham, and J. J. Nibbs, Assist.-Engineers, to the *Victoria*; W. Thomson, J. Adamson, T. T. Truscott, G. J. James, and J. R. Atkins, Second-class Assist.-Engineers, to the *Asia*; G. A. Wells, Engineer, to the *Dauntless*, for tenders; S. J. Bird, Assist.-Engineer, to the *Asia*, for hospital treatment; J. Williams, Assist.-Engineer, to the *Racoon*; J. H. Fergusson, Assist.-Engineer, to the *Irresistible*; W. C. Hilder and A. Borthwick, Engineers, to the *Terror*, for disposal; W. Bryan, A. Ritchie, J. R. Butters, and J. Runnals, Assist.-Engineer, to the *Terror*, for disposal; T. Stead and C. A. Walmisley, Assist.-Engineer, to the *Victoria*, as supernumeraries; R. Spiers and G. H. Wicks, Assist.-Engineers, to the *Victoria*, as additional; W. Miller and J. M. Sales, Engineers, to the *Fisgard*, as supernumeraries; B. R. King, of the *Industry*, and J. M. Watson, of the *Rattlesnake*, promoted to be First-class Assist.-Engineers; W. A. M. Vivyan, Assist.-Engineer, to the *Indus*; W. F. Coope, Assist.-Engineer, to the *Cumberland*; W. Lewis, Chief Engineer, to the *Indus*, for the *Sphinx*; H. Kight, Engineer, to the *Fisgard*, as supernumerary; G. Hunt (b), Engineer, to the *Fisgard*, for the *Landrail*; C. B. Cresswell, Engineer, to the *Pembroke*, for the *Tender*; J. M. Murphy, Engineer, to the *Indus*, as supernumerary; D. Anderson, of the *Indus*, promoted to First-class Assist.-Engineer; A. Forrester, of the *Blenheim*, for the *Julia*, promoted to First-class Assist.-Engineer; J. Leeson, Assist.-Engineer, to the *Donegal*; D. Gibb, Assist.-Engineer, to the *Indus*, as supernumerary; H. H. Gulliver, J. G. Ellis, H. G. M'Queen, G. Ball, W. Oates, H. G. Johnstone, J. Sharp, J. W. Scoble, H. G. Bonrke, and Felix Forman, Acting Second-class Assist.-Engineers, to the *Indus*; G. J. W. Bridle, W. Nicklin, W. Olive, and J. Hobbs, Acting Second-class Assist.-Engineers, to the *Asia*; J. G. Goff and W. J. Pettit, Acting Second-class Assist.-Engineers, to the *Fisgard*: R. L. Butler, R. Pearce, and T. H. Middleton, Acting Second-class Assist.-Engineers, to the *Cumberland*; R. J. Wheeler, Acting Second-class Assist.-Engineer, to the *Fisgard*, for the *Vivid*; E. G. Cooper, Acting Second-class Assist.-Engineer, to the *Fisgard*, for the *Widgeon*; F. W. Sutton (b), Chief Engineer, to the *Cumberland*, for the *Serpent*; W. R. Leeson, Engineer, to the *Indus*, for the *Bann*; W. Roberts, Engineer, to the *Indus*, for the *Asp*.

MILITARY ENGINEERING.

Rodman's Gun.—A 20in. Rodman gun was recently tried with success at New York; it weighs nearly 117,000lb. Its diameter or thickness is nearly 6ft. at the breech, and its bore is 20in. The solid shot it throws is 1,080lb. in weight, and the regular charge of powder is 100lb., which may be increased to 125lb., with which charge it will carry five or six miles.

STEAM SHIPPING.

Atlantic Steamers.—On the 17th ult. the new Cunard steamer *Cuba* arrived in the Mersey from Glasgow, where she was built and launched in July last. The *Cuba* is an iron screw vessel, sister to the *China*. In length the *Cuba* measures 350ft. over all; she is 42ft. 6in. in moulded breadth of beam, and is 28ft. deep. She is of 2,700 tons builders' measurement, and is propelled by two oscillating engines, furnished with surface condensers, and having cylinders 82in. in diameter, and a piston stroke of 6ft., giving a result of

600 horse-power. With this power, small compared with the great bulk of the vessel to be driven through the water, she, on the occasion of her Admiralty trial, accomplished the distance between the Cloch and Cumbrae Lights, 13·666 nautical, or 15·774 statute, miles in little more than an hour, both ways, as it happened, against the tide. This, however, gives little indication of her speed, for, in addition to her steam power, the ship is full masted and sparred, carrying great stretch of canvas. She was built by Messrs. Tod and Macgregor, of Meadowside. On the 15th ult. the new Inman steamer *City of Boston* was launched from the yard of Messrs. Tod and Macgregor, at Meadowside, Partick. Her dimensions are:—Length of keel and forerake, 305ft.; breadth of beam, moulded, 39ft.; depth, 27ft. 6in.; tonnage, o.m., 2,278. The hull is built in six water-tight compartments. The propelling power will be supplied by a pair of direct-acting trunk engines of 350 horse-power. The cylinders will have a diameter of 36in., with a stroke of 3ft.; and the engines will be fitted with patent surface condensers.

Steam Shipbuilding on the Clyde.—Messrs. Inglis, of Point-house, have launched a screw of 580 tons, for a French firm. The steamer, named the *Bayo*, will be fitted by the builders with direct-acting engines of 90 horse-power. She is constructed to carry a large cargo with a moderate draught of water. The steamer *Hattie*, originally built for the Wemyss Bay Railway Company, but afterwards sold for blockade-running purposes, has run the lights at the rate of 19 miles per hour; she was built and engined by Messrs. Caird and Co. Messrs. Aitkin and Mansel, of Whiteinch, have launched a paddle of the annexed dimensions:—Length of keel and forerake, 250ft.; breadth of beam, 31ft.; depth moulded, 12ft. She was named the *Florence*, and is being fitted with oscillating engines of 250 horse-power, by Messrs. J. Aitkin and Co., of Cranston-hill. Messrs. C. Connell and Co., of Overnewton, have launched an iron screw of 650 tons, for Messrs. Handysides and Henderson, who propose to employ her in the Mediterranean trade. She was named the *Napoli*, and is the fifth steamer built by Messrs. Connell and Co., for the same firm. Mr. T. B. Seath, of Rutherglen, has launched the *Voldroque*, the fifth steamer which he has built to the order of the Haytian Minister, for passenger traffic in Hayti. The dimensions of the *Voldroque* are 156ft., 20ft., and 14ft. The *Aleppo*, screw 2,000 tons, has been launched from the yard of Messrs. J. and G. Thompson, of Govan. She is the first of a new fleet building for Messrs. Burns and M'Iver, of Liverpool, and is intended for their Mediterranean service. There are no less than 14,000 tons of steam shipping building on the Clyde for the same firm. Messrs. Caird and Co., have launched the *Gyptis*, a screw of 1,080 tons, old measurement. She is 264ft. in length at the load line, 29ft. 9in. beam, and 24ft. depth of hold. The engines are to be put on board by the builders, and will be direct acting. The *Gyptis* has been built for MM. Fraissinet Père et Fils, of Marseilles, and will run between Marseilles and Constantinople with passengers and goods. Messrs. Barclay, Curle, and Co. have launched a screw of 700 tons register. The vessel's principal dimensions are—length, 222ft.; breadth, 29ft.; depth of hold, 15ft. She is to be fitted with geared engines of 11·5 horse-power by the builders. She is owned by the Leith, Hull, and Hamburg Steam Packet Company, is intended for their Baltic line of steamers, and is a sister ship of the Danzig, launched lately by Messrs. Barclay, Curle, and Co., for the same owners. Mesrss. W. Denny and Brothers, of Dumbarton, have launched an iron screw of 1,650 tons, built for the Austrian Lloyd's Steam Navigation Company. The steamer, which was named the *Juno*, is a duplicate of the *Jupiter*, recently launched by the same builders for the same company. Messrs. Tod and Macgregor, of Patrick, have launched the *City of Boston*, an iron screw, built for the Inman line. The *City of Boston* is the eleventh steamer built by Messrs. Tod and Macgregor for the same company, and is of the annexed dimensions:—Length of keel and fore-rake, 305ft.; breadth of beam, moulded, 39ft.; depth, 27ft. 6in.; burden, 2,278 tons, old measurement. The steamer, which is built in six water-tight compartments, will be propelled by a pair of direct-acting trunk engines of 350-horse power. The *City of Washington*, one of the older vessels of the Inman fleet, has just been taken to Messrs. Tod and Macgregor's works to be overhauled and refitted, after having made 126 voyages across the Atlantic. Mr. Inman, managing director of the company, has also ordered another steamer from the same firm. Messrs. Henderson, Coulborn, and Co., of Renfrew, have launched a blockade-runner 223ft. long, 25ft. broad, and 13ft. deep, and a duplicate of the *Coquette*, which has proved herself an uncommonly smart and successful craft in connexion with this peculiar business. The new steamer is being fitted with a pair of geared engines of 150-horse power nominal, and constructed on the builders' diagonal oscillating principle. Messrs. M'Nab and Co. have launched a screw, named the *Colombian*, built for Mr. A. Holt, of Liverpool. She is intended for the West India trade, and has direct-acting engines, put on board by her builders. The *Douro*, screw, built by Messss. Harland and Wolff, of Belfast, for Messrs. J. J. Bibby, Sons, and Co., of Liverpool, is receiving her machinery, which is being supplied by Messrs. M'Nab and Co. The *Douro* is the tenth vessel engined by the same firm for the same builders. The *Cuba*, built by Messrs. Tod and Macgregor, for the Cunard line, has made an excellent run from the Clyde to the Mersey, and is now ready for service.

The Trial Trip of the "Brittany," paddle steamer, 525 tons burthen and 250 horse-power, built for the South-Western Company by Messrs. Ash and Co., and engined by Mr. John Stewart, took place on the 11th ult. at the measured mile in Stokes Bay. Immersed to her full sea-going capacity, and with very strong winds blowing, she realised an average speed of 14 knots, or 16 statute miles per hour; and after leaving Stokes Bay she was taken for a run out into the Channel, 10 miles beyond the Nab Light, during which an accelerated speed was obtained of 17 miles per hour.

The "Anna Liffey."—On the 8th ult. the trial of this new steamer, built by Messrs. Walpole and Co., of Dublin, for the Dublin and Kingstown Steam Packet Company, took place. The highest speed attained was 16½ knots per hour, the vessel traversing the distance from the West Pier to the Northwall Lighthouse in 26 minutes.

LAUNCHES.

The Humber Ironworks and Shipbuilding Company.—On the 18th ult., there were launched from this shipbuilding yard three large iron ships, one a steamer and the others sailing barques. The first vessel sent off the stocks was named the *Norseman*, and has been built for the Liverpool firm of Cotesworth and Lynn. She is intended for the South American copper ore trade. Her dimensions are—length between perpendiculars, 170ft.; moulded breadth, 28ft. 6in.; moulded depth, 19ft. 8in.; depth of hold, 18ft. 3in.; tonnage, 660⅓, old measurement. She is to be rigged as a barque. The next was the *Alexandra*, which is 216ft. long; breadth, 36ft.; depth of hold, 23ft.; tonnage, 1,340. The *Alexandra* was built for a Liverpool firm, and is intended for the East Indian trade. The third launch was that of a steamer which was named the *Norfolk*. She has been built for Messrs. Bailey and Leetham, of Hull, for the Baltic trade. Her length is 240ft.; breadth, 36ft.; depth of hold, 19ft. 9in.: tonnage, 1,097.

Launch of a Steamer for the Indus Flotilla Company.—Messrs. J. Wigham, Richardson, and Co., have launched from their yard, at Low Walker, a paddle-wheel steamer for the Indus Flotilla Company. The *Sir Herbert Maddock* was launched from the same berth as the Royal West India Mail Steamer *Tyne*, built by Messrs. Miller, Ravenhill, and Co., when they had possession of the yard. She is of exactly the same length, viz., 280ft. Her beam is 28ft., and is to be fitted with engines of 300 nominal horse-power, by Messrs. R. Morrison and Co., of Newcastle, consisting of two oscillating cylinders, each of about 6ft. in diameter. The framing which carries them and the shafting is forged in one solid mass, forming a structure combining great lightness with immense strength. There are four boilers, intended to work at a higher pressure than usual. The present steamer differs essentially from former vessels sent out, and the contractors have perfect confidence that they will be able to fulfil the conditions specified by the company. She will be thorougly tried on this river, and then taken to pieces for transmission to India. At Messrs. Richardson's some barges are in course of completion, which are to be towed on the Indus by the *Sir Herbert Maddock*, taking up the river to the dense population of the Punjaub those articles of English manufacture which are fast becoming to them necessaries of life, and bringing down the cotton which is so much wanted in Lancashire.

TELEGRAPHIC ENGINEERING.

The Atlantic Telegraph.—There are seven copper wires to form the conductor. The entire length of the telegraph will be 2,300 miles, so that there are 16,000 miles of copper wire. Every portion of this copper wire is subjected to electrical test, to ascertain its quality for conduction before it is allowed to be worked up. The next stage is to coat these wires with eight successive coats of the insulating material, equal to an aggregate length of 18,400 miles. This core is next covered with jute wound round it from ten strands, making 23,000 miles of jute yarn. Then comes the outer coating formed of the ten covered iron wires. The iron wire itself is 23,000 miles in length, and each wire is covered separately with five strands of tarred hemp, 135,000 miles of the latter being required, making together an aggregate length of material employed of 215,500 miles, or very nearly as much as would put ten girdles round the earth, or form a line that would stretch almost from the earth to the moon.

RAILWAYS.

Fire at a Railway Station.—A fire occurred on the 12th ult. at Worcester, at the Shrub Hill Railway Station, where there are extensive works. Although the station itself suffered no injury, buildings extending over an area of nearly an acre were destroyed. The damage is estimated at about £20,000, and more than 400 workpeople are thrown out of employment.

The Midland are about to obtain a separate entrance into London. Instead of joining the Great Northern system at Hitchen, as hitherto, the Midland will strike off at Bedford, and run in an almost direct line into London, by a line now in course of construction. There will also be a branch of about one mile to connect the system with the Metropolitan Railway. The cost of this is estimated at £150,000, but the company will have in return direct access not only with the heart of the city, but will also have communication with the whole of the lines south of the Thames by means of the bridge at Blackfriars.

The South-Western Railway Company and the London, Chatham, and Dover.—An agreement has been made between these companies by which the former will obtain access over the lines of the latter to the Ludgate-hill Station, and thence over their City Junction line to the Metropolitan and Great Northern Railways at Farringdon-street.

The London and North-Western Railway Company have commenced running passenger trains to and from Swansea in connection with their joint Shrewsbury and Hereford line, and the narrow gauge communication is now complete from South Wales to the North and Midland districts of England.

Testimonial to a Railway Engineer.—A magnificent service of plate, weighing 1,000 ounces, and of the value of £650, was presented to Mr. J. C. Forsyth, engineer of the North Staffordshire Railway, and also for some years general manager of that line, at a banquet given to him at Stoke-on-Trent on Friday evening last. The testimonial was subscribed by a number of gentlemen residing in North Staffordshire, and was intended, to quote the inscription on one of the pieces of the service, "as a tribute of respect and admiration for the honest, independent, and able manner in which he has discharged his duty as resident engineer of the North Staffordshire Railway from its commencement, and also as general manager of the whole undertaking for a number of years."

Proposed New Branch Railways near Halifax.—Steps are being taken for making branch lines near Halifax from the Lancashire and Yorkshire Railway, one starting at North Dean and running to Holywell Green, Stainland, and the other beginning at Luddenden Foot and running a little above Luddenden.

Railway Passengers' Signal.—Mr. Edmund Tattersall's plan for giving railway passengers a means of communication with the guard in case of accident has been submitted to the chairman and directors of the London and South-Western, at the Waterloo station. A carriage on that line had been placed at his disposal for some time past, fitted up with the apparatus, under the superintendence of the engineer of the company, and several trials run with it, and with perfect success. The trials were repeated on Thursday, in presence of the officials, and with results which were gratifying to all present. The invention, which is patented, points out at once to the guard, by day or night, the carriage, and even the compartment, from which the alarm signal is given. Each passenger can use the signal without moving from his seat, and each carriage has its own separate apparatus.

A new First-class Railway Carriage has been constructed in France. It contains as many places and is as commodious as those at present in use. A passage, which traverses the carriage in its full length and leads to a water-closet, permits the guards to keep a strict watch over all that passes during the progress of the train. The travellers, moreover, can walk and smoke on a covered platform placed at each end. The construction does not cost more than ordinary. The Strasbourg Railway Company have used this new carriage on their line for several months, and travellers avail themselves of it in preference to all others.

RAILWAY ACCIDENTS.

Collision on the West Midland Railway.—An accident happened on the night of the 4th ult., on the West Midland section of the Great Western Railway, at Norton Junction, by which several passengers in a Midland train were much injured, and property to a considerable extent destroyed. This portion of the West Midland line forms a loop of the Midland Railway between Abbot's-wood and Stoke (about twelve miles), and the Midland trains from Gloucester to Bristol pass over it in common with the West Midland trains. Every train as it leaves Worcester for London or Gloucester is telegraphed to Norton Junction; the first train from Birmingham to Bristol left Worcester at about the regular time—3.10 p.m., and was telegraphed to Norton. At the time when the train from Birmingham to Bristol was signalled from Worcester as having left that station a goods train was being shunted at Norton Junction, and the signal-men put up the danger signal. The driver of the Birmingham train not seeing the signal, passed it, and proceeded on towards Norton Junction, when he met the goods train, which was just emerging out of a siding on to the main line. The result was that the two engines came into collision, the passenger engine was turned off the main line, and, running for a short distance along, ploughed into the earth, turned on one side, and stuck fast at a considerable angle. The connecting rods, step, wheels, axle-boxes, and all projecting portions of the engine were torn away as if they were paper, and iron rods of 15in. in circumference were snapped like sticks.

Railway Collision on the Midland Railway.—On the night of the 4th ult., a collision occurred on the Midland Railway, at the Water-lane junction, near Leeds. At this point, which forms one of the angles of a triangular system, the lines of rails from the Wellington station and from Holbeck join. The accident was caused by the passenger train for York and Hull, which leaves the former station at 7 p.m., coming into colli-

sion laterally with a goods train which left Holbeck for Hunslet-lane at about 6.40 p.m. Through some misunderstanding with regard to the signals, both trains were allowed to approach the junction at the same time. The point would have been cleared by the passenger train had a minute more been allowed; but at the moment when it was passing on to its own line of rails it came in contact with the goods train, the engine and tender of which it threw on the six-feet way. The goods train was moving slowly, the other with some rapidity. The passengers were a good deal shaken.

DOCKS, HARBOURS, BRIDGES.

The Proposed New Bridge over the Tyne.—At the River Tyne Commissioners' Rooms, a model of the proposed swing bridge over the Tyne, on the site of the existing old Tyne bridge, has been on view. It is the design of Mr. Ure, the engineer to the Commissioners. The bridge has received the sanction of the Board of Trade. It will cross the river on the site of the present structure. It will be of iron, and its width is to be 45ft. or 11ft. greater than that of the existing viaduct. About 25ft. will be given to carriages, and 10ft. on each side to foot passengers. Midway in the river a transverse pier will extend from the west side of the high-level bridge at its central pier to the east side of Tyne bridge, forming a platform between the two viaducts, and the swing, when thrown open, will overlie this pier. The engineer has made provision for all the requirements of traffic, both on and over the water, and on the banks of the river.

The Whitcomb Reservoirs at Gloucester.—A report from the surveyor was read at a recent council meeting, in which he stated that he had prepared plans and sections for the repairs in regard to the slip at the Whitcomb reservoirs. The work would be finished in a fortnight. He had discovered that the slip was greater than had at first been supposed. The earth had moved horizontally 20ft. at the foot of the slip, and for a length of 110 or 120ft. along the embankment. It would require 6,000 tons of stone, and that quantity would soon be used. The total cost incurred up to the 8th of October was £1,170 10s. 8d. The approximate estimate for completing the work was £70 5s.,—total, £1,240 15s. 8d. The estimated cost, as submitted on the 12th of August, was £1,004 10s. The excess over the original estimate was due to the necessity of having upwards of 2,000 tons of stone more than was at first thought requisite.

Proposed Railway Bridge over the Tay.—A meeting of the principal inhabitants of Dundee has been held to consider a proposal to form a high-level bridge across the Firth of Tay. Mr. Dodds, parliamentary solicitor, stated that the scheme was brought forward in connection with a proposed bridge over the Forth above Queensferry. Mr. Bouch, C.E., stated that a line was intended to run along the south shore of the Firth, from Tayport to Newport (about two miles and a half), from which it would cross to Dundee on a lattice girder bridge, about two miles in length, with a single line of rails. A double line would run nearly a mile through the town on arches to the general station, where the North British would join the Scottish North-Eastern. The estimate was, for the Tayport line, £70,000; the bridge, £180,000; the junction line, £100,000—in all, £350,000. The Forth bridge would cost about three times that of the Tay bridge. The southern and east coast companies were to build the Forth bridge, and would also give aid to the Tay bridge, but it was hoped the people of Dundee would show their interest in the scheme by subscribing part of the capital. The bridge would be finished in about two years. It would not, being above the port and harbour of Dundee, interfere with the navigation, its elevation being about 100ft. above the fairway at high water, the same height as the Britannia bridge, reduced at the ends by an incline on either side of 70ft. The meeting expressed general approval of the object, and appointed a committee to consider the scheme maturely and report upon it.

The Railway Bridge over the Forth.—The North British and Edinburgh and Glasgow Railway Companies have, it is stated, agreed to jointly promote a bridge over the Frith of Forth, at or near the site proposed in the Glasgow and North British scheme of last year. The bridge requires short new lines to connect with the] Edinburgh and Glargow system on the south side of the Firth, and with the North British lines on the Fife side. There will be no essential variation in the character of the bridge from that proposed last year. There will always be sufficient traffic to warrant the maintenance of the Granton and Burntisland Ferry on the present or even on an extended scale. But the recent severe weather has occurred rather opportunely to exemplify the inconveniences of a sea passage as part of a through railway traffic. The proposed railway bridge from Newport to Dundee was all that was needed to complete the annihilation of the ferry obstructions; and though this scheme is being promoted by an independent company, it will, of course, receive substantial support from the railway companies who are chiefly to be benefited.

Clifton Suspension Bridge.—On the 5th ult., the testing of the Suspension Bridge was effected with most satisfactory results. A mass of stone equal to five hundred tons was laid upon the structure so that the full strain should be on the suspended portions of the bridge between the buttresses. That enormous weight was allowed to remain upon the structure for seven hours; the only effect produced was a deflection of about seven inches in the centre, the natural result of the tension of the iron and the straightening of the land chains which run from the anchorage to the top of the buttresses.

The New Pier for Weston-super-Mare.—A company was lately started with the view of constructing a pier, the capital being £20,000 in 2,000 shares of £10 each. The site fixed upon is opposite the island of Bernbeck, the northern point of the bay on which the town is situate, the object being to connect the island with the main land. The pier will start from the main land from a stone abutment. On that will be placed stone buildings, which will be used as toll-houses, between which will be entrance-gates in style with the structure. The main body of the pier, which will be 1,000ft. in length, and in width 20ft., will rest on wrought-iron columns, and the roadway will be of wood, covered with asphalte. On either side of that a continuous line of seats will form an agreeable lounge for visitors.

The New Graving Dock, Sunderland.—The first portion of this new graving dock is drawing towards completion. The total length of the dock, when finished, will be 420ft., the first portion now in course of construction being 250ft.; the width at the bottom is 40ft., and at the top 75ft.; the entrance at the top is 60ft. wide; and the depth of water on the sill at high-water is from 16ft. to 17ft. The dock has been constructed so as to give great facilities for the repair of both iron and wooden vessels, and the sides are a series of easy steps, which are sloped, so as to admit the fullest amount of light during the short days of winter. The caisson is being completed by Messrs. Hawks, Crawshay, and Sons, of Gateshead.

Great Bridge over the Seine.—The Western of France Railway is having constructed for a direct line from Rouen to the Paris and Cherbourg line a great bridge over the Seine. The bridge reposes on five cast iron piers, the distance between each being 166ft., so that the total length of the bridge is 933ft. It is constructed for two lines, and is about 45ft. in width. The contractors are the Creuzot Works.

New Pier at Mevagissey.—The old pier at Mevagissey having proved of late quite inadequate to give the accommodation the increasing trade of the port requires, the trustees have instructed Messrs. Jenkin and Trathan, civil engineers of Liskeard, to prepare the necessary specifications and estimates for a new pier, and will apply to Parliament for an Act authorising its construction. It is proposed to construct an arm from a rock on the east side of the entrance to a pool called Black Rock, for about 500ft. in a south-westerly direction. This would enclose an area, including the existing pier, of about 16 acres, with a depth of 15ft. of water at low water spring tides.

MINES, METALLURGY, &c.

Enormous Casting, Sheffield.—In July last a successful attempt was made by Messrs. J. M. Stanley and Co., the Midland Works, to cast an anvil block weighing 169 tons. The enormous mass of iron took six weeks to cool, and it was then, by means of hydraulic power, lifted from the mould. Recently the same firm were engaged in casting a second anvil of precisely the same size and weight. The mould, which was 12ft. square at the base and 11ft. 6in. deep, was dug out in the centre of the workshop, and from the five furnaces constructed at intervals round the building, the molten iron was run. The first furnace was "tapped" at six o'clock in the morning, and in about twelve hours the mould was filled.

Preservation of Iron in Water.—At a sitting of the Academy of Sciences M. Becquerel read a paper on the preservation of cast iron and iron in fresh water. He had previously shown that when a plate of either material was in contact with a zinc plate not exceeding the hundredth part of the surface of the former, the intensity of the derived electrical currents on the protected metal (iron) would, in sea water, diminish as the distance from the point of contact of the two metals increased; but nevertheless so that the protection afforded by these derived currents would still extend to a considerable distance from the said point of contact. In fresh water there are fewer divided currents on the surface of the metal, a fact which M. Becquerel attributes to the difference of conductability of the two liquids and the degree of chemical action which each exercises on the zinc, since these two circumstances both tend to increase the intensity of the currents. M. Becquerel concludes with saying that a pile of 9,837 cannon-balls, 12 centimetres in diameter, may be protected from oxydation under water by surrounding it with zinc bands having an aggregate surface of two square metres.

Great Deposit of Lead Slag in Greece.—At the Imperial Geological Institute of Vienna meeting, on Aug. 16, Baron von Hingenau stated that at the lead mines of Laurion, in Attica, worked for many centuries but now abandoned, there is an accumulation of slag estimated at about 2,000,000 tons, which, according to assays made at Marseilles, produces, on an average, from 6 to 10 kilos. of lead and 3 grammes of silver per 100 kilos., equals from 6 to 10 per cent. of lead, containing from 6 to 9½ ozs. of silver per ton. A French company has undertaken the working of this slag, paying about £1,800 to the Greek Government, and an annual rent of about £75 to the owners of the ground. Buildings, furnaces, engines, &c., have been erected for metallurgical operations at a cost of 500,000fr. (£20,000).

Cementation of Iron.—At the Academy of Sciences, M. Margueritte communicated a paper on the Cementation of Iron. M. Caron having laid down the theory that, in cementation on a large scale, iron is always brought into contact with cyanides, which alone possess the power of cementing, M. Margueritte proves, on the contrary, that iron may be converted into steel by pure carbon (that is, by either diamond, carbonised sugar, or plumbago), or else by the pure oxide of carbon.

New Alloy for Iron.—At the American Institute, Prof. Fleury read a paper on a new alloy of copper, zinc, and tin to be mixed with iron, recently patented by Mr. Arnold. It was stated that 5 to 10 per cent. of the mixture added to cast iron increased the tensile strength of the iron several thousand pounds to the square inch, as proved by tests at the West Point Foundry.

Lignite in Turkey.—A large deposit of lignite has been lately discovered at the Jumowassi station of the Ottoman, Smyrna, and Aiden Railway, thirteen miles from the city of Smyrna. Two other deposits are known and worked near the line—at Sokia and Nashe, in the interior; these approach the character of lignitic coal, like that of Chib, but the Jumowassi variety is a pure lignite. It is found in abundance to the depth of 5ft., where water is encountered. It burns freely, and is now under trial in Smyrna. From specimens lately discovered near Ephesus and Azirieh there is strong reason to believe the existence of minerals of lead and antimony in the Ephesus Pass, near the great tunnel, and of iron at Azirieh. In the neighbourhood are emery and lignite deposits, and in the same district are the ancient and modern workings of the rich hematite iron deposits of the Besh Parmah Mountains. The geological structure gives a promise of gold diggings in the valley of the River Cayster, near the railway. Copper was detected in former workings of the Saladin continuation of the Ephesus Mountains.

Coal in India.—Coal has been discovered at Dandote and Makrach, in the Bombay Presidency, and it has been tried with great success on the Punjaub Railway. The locomotive superintendent on this railway has reported at length upon the trials. The results of the experiments are most satisfactory. The combustion was almost perfect, and very little clinker was made.

Trial of a New Machine for Getting Coal.—On the 6th ult., a coal cutting machine on an entirely new principle, the invention of Messrs. Lock and Warrington, colliery owners, Kippax, and Messrs. Carrett and Marshall, engineers, Leeds, was tried at the Kippax Colliery, near Leeds. The coal cutting machines which have been tried recently in other districts have been worked by compressed air, and on the principle of the pick motion. This machine is, however, worked by water pressure at 150lbs. to an inch, conveyed in 1½in. wrought iron pipes, from a small engine fixed near the bottom of the pit. The trial was made in the Allerton seam of coal, which is 5ft. 6in. thick, but contains a layer of dirt 3in. thick at the height of 20in. from the floor, which separates the hest and seconds seams of coal. The machine was mounted on four wheels, and traversed on the corf tramways. The "holing" or "baring," which is the hardest and most laborious part of the collier's work, was done remarkably well, in one even straight line, and to a uniform depth, at once going over, making 25 strokes per minute. The cutters were fixed in a slotting bar, worked with a steady longitudinal reciprocating motion at a slight angle, which ripped out the whole of the partition of dirt to a depth of 3ft. 3in. The apparatus being entirely self-acting in all its operations, it propelled itself forward, secured itself dead fast between the floor and roof, whilst the cutters were in operation, and again released itself with the return stroke. The machine is strong, and not at all complicated, and is likely to work with durability. One man is all that is required to attend to it, and he has nothing to do but to set it in motion and stop it when required. The machine worked on this occasion two hours forty-nine minutes, and excavated the dirt out 3in. thick and 3ft. 3in. under for a length of twenty-two yards and two feet, and liberated from the solid bed of coal forty-four tons. The average cost of "baring" by hand labour at the same colliery is 8d. per ton; but the principal saving is in the economical working of the coal without cutting such a large proportion into slack as is done by hand labour. The pressure of water can be increased to any required extent, and its quantity needs only to be enough to fill the circuit of the pipes,—the same fluid thus being used over and over again to convey the power any required distance from the source of power to the coal seam to be operated upon. Messrs. Lock and Warrington are so well satisfied with the advantages of getting coal by machinery that they are making more machines in order to take all their coal worked by them.

Copper in Spain.—M. Tribaut, a French mining engineer, has lately discovered a very rich vein of cobaltiferous copper, containing nearly 9 per cent. of oxide of cobalt, near Oviedo, in Spain. He has entered into an agreement with an English house to take nearly the whole produce of his mines.

The Iron of Lake Superior.—We extract the following from the *Toronto Globe*:—The discovery of vast deposits of iron ore near Goulais Bay, on the Canadian side of Lake Superior, is a matter of no ordinary importance. For some time it has been known that iron existed on Canadian territory, near Fort William, but the extent of the beds has not been made known by exploration, and their situation is not peculiarly favourable for

working. The discovery of large quantities of ore at the eastern end of Lake Superior, not far from Sault, within five miles of a good harbour, is a horse of an entirely different colour. We look upon every fresh discovery of mineral wealth upon the northern shores of Lakes Huron and Superior as of immense importance in reference to the question of North-western extension. It is useless to deny that the territory on these shores is not one peculiarly fitted to maintain an agricultural population. It does contain much good land capable of supporting a considerable number of persons, and its timber is in many places valuable. But its climate is ungenial, and its soil is neither so fertile nor so easily worked as the prairies of the West, with which it competes for occupants. It is plain that, if it is to be rapidly settled, it must be by means of its mining riches. Copper, lead, and nickel exist in abundance, and no contemptible indications of silver have been found. Iron has now been added to the list, an article which is likely to attract a larger population than any of the others, so vast is the quantity consumed. If, by means of the mines which are being opened along the coast, settlements can be formed and roads constructed, we shall attain to that much desired object, the bridging over of the gaps of rough and partially barren country which lie between us and the fertile prairies of North-western British America. Progress is being made in this direction, and every fresh discovery of ore gives it an impetus. The formation of lumbering establishments on the Georgian Bay, the projection of new mines near the St. Marie river, the extension of the settlements at the Sault, the opening of copper and lead mines at the upper end of the lake, the permanent establishment of the steamer route to Fort William, are all steps in the right direction. The report of Mr. C. E. Anderson, Government Commissioner, who has recently visited all parts of the Algoma district, will, we hope, lead to great reforms in the Government regulations for the sale of mineral and other lands, and inaugurate a new era ot progress.

GAS SUPPLY

Gas in Moscow.—The Hague *Dagblad* state M. N. D. Goldsmid, of that town, has acquired a concession for lighting Moscow with gas. It is granted for thirty years, and gives him an exclusive privilege of laying gas-pipes and other fittings in the streets of Moscow for that time. The number of public gas-lamps is to be 10,000, and private buildings will require 150,000 lights. Moscow has more than 400 hotels and 3,000 coffee-houses, inns, and gin shops; these are open all night, as the inhabitants seldom go to bed before two or three in the morning, and during the winter scarcely ever remain in the street. The number of shops and magazines is four times greater than in St. Petersburg. According to the terms of the contract, the gas will cost for the private lighting 5 roubles, or 9f. 50c., per 1,000 cubic feet (English measure). The concession will require colossal gasworks, but there can be no doubt it promises, in a financial point of view, good results.

Destructive Gas Explosion.—On the morning of the 5th ult. an explosion took place at Heckmondwike, in the West Riding. It appears that a large four-storey corn-mill had been almost totally destroyed by an explosion of gas, and that a man who had charge of the mill in the night-time had been so fearfully injured as to render his recovery hopeless. Not only were the roof and sides of the mill reduced to ruins, but many tons of flour and meal were scattered in all directions, so that the immediate locality presented an appearance as if a fall of snow had recently taken place.

Lenoir's Gas Engine.—We have already had occasion to refer to this motor, which is intended as a means of obtaining the equivalent of steam-power in cases where the use of steam could not be admitted. In outward appearance, the Lenoir gas-engine does not differ widely from that of a horizontal steam-engine; but, with the gas-engine, the necessity for boiler and furnace, with the accompanying expense of stoker and fuel, does not exist. The power is generated within the cylinder itself; and, as no more is generated than is actually required for the stroke to be made, there can be no waste whilst the engine is at work, and the expense will cease entirely the instant the engine is stopped. After lying some time in abeyance, the development of Mr. Lenoir's invention in this country has been undertaken, it is said, and will be energetically carried on, by the Reading Ironworks Company, who propose to construct the machine in four sizes, from ½-horse to 3-horse power, the price of which will vary from £55 to £125; and these amounts include the electric apparatus connected with the machine, which will require only the gas to be turned into it to set it to work. An annual royalty of from £2 2s. to £3 3s. is charged for the right to use the engine during the continuance of the patent; but this may be commuted by a small immediate payment.

Gas-Meter Company (Limited).—At the second annual meeting of this company a dividend was declared at the rate of 6 per cent. per annum for the last half-year, and for the same period a bonus at the rate of 6 per cent. per annum, leaving a balance of profit undivided of £768. The company have completed arrangements for the more accurate formation of dry gas-meters by machinery, for which they have a patent. The report states that 13,000 of their "unvarying water-line gas-meters" (Sanders and Donnovan's patent) are at present in use. The consulting engineer of the company, Mr. T. G. Barlow, has reported to the directors on the dry-meter machinery.

WATER SUPPLY.

The Water Supply at Trowbridge.—A scheme is on foot for establishing a Water Supply Company, with a capital of £25,000, in 2,500 shares of £10 each, whose object shall be to establish water works for the purpose of supplying the inhabitants with pure spring water, which is to be supplied by meter, as the gas now is, and at a charge of 2s. 6d. per 1,000 gallons, through mains to be laid down in the principal thoroughfares; and it is intended to charge these various mains at a pressure sufficient to reach the highest factory in case of fire, thus dispensing with the use of fire-engines.

Water Supply at Bath.—A report has been presented to the town council by the city engineer, Mr. Alfred Mitchell, on the subject of an additional supply of water to Bath. The engineer recommends the use of the numerous springs in the St. Catherine Valley, and he has prepared plans of works, including a high-level reservoir at the head of the valley, 14 acres in extent and 45ft. in average depth, and capable of containing 90,000,000 gallons, at an elevation of 287ft. above the Abbey pavement—as also a low-level reservoir in the Oakford Valley, to contain 20,000,000 gallons, at an elevation of 150ft. above the Abbey pavement level. The cost of the proposed supply he estimates at £66,058.

APPLIED CHEMISTRY.

Preparation and properties of Rubidium.—In the "Annalen der Chemie und Pharmacie," Professor Bunsen gives an account of his last experiments on rubidium. The latter may be reduced from carbonated acidiferous tartrite of oxide of rubidium (in a manner similar to the reduction of kalium). 75 grains of that salt will yield 5 grains of pure metal melted to a compact mass. It is very light, like silver; its colour is white with a yellowish *nuance* hardly perceptible. In contact with air it covers itself immediately with a bluish grey coating of suboxyd, and is inflamed (even when in larger lumps, after a few seconds, much quicker than kalium. At a temperature of 14° F., it is still as soft as wax; it becomes liquid at 101·3° F., and in red heat it is transformed into a greenish-blue vapour. The specific gravity of rubidium is about 1·52. It is much more electropositive than kalium, if combined with the latter to a galvanic chain by acidiferous water. The rubidium, thrown on water, will burn and show a flame of the same appearance as that exhibited by kalium.

A New Hydrocarbon in the Coal Tar Series.—M. A. Bechamp recently announced to the French Academy of Sciences the discovery of a new hydrocarbon in the mixture that makes up coal tar. In rectifying with care the products which boil between 130 deg. and 150 deg. Cent. (266 deg. and 302 deg. Fahr.), M. Bechamp observed that the thermometer remained a long time stationary in the neighbourhood of 140 deg. (Cent.) a temperature midway between the boiling points of xylole and cumole. Keeping this temperature constant, he separated from thirty measures of brown tar one measure of a liquid hydrocarbon. A new rectification allowed the whole of this to pass between 139 deg. and 140 deg. This constancy of the boiling point forbids the supposition that it is a mixture of xylole and cumole. By further purification with concentrated sulphuric acid and sodium the author finally succeeded in producing in the neighbourhood of 900 cubic centimetres of a product boiling from the commencement to the end of a temparature between 139 deg. and 140 deg. (282 deg. and 284 deg. Fahr.)

On a Means of Detecting Nitro-benzol in Oil of Bitter Almonds, by M. Dragendorff.—This test consists in acting on the adulterated oil with sodium in the presence of alcohol. This metal, in contact with pure oil of bitter almonds, disengages gas, which is augmented by the addition of alcohol, and white flocks are formed. Nitrobenzol under the same circumstances with alcohol becomes deep brown or black and viscid. In testing the adulterated oil, take ten or fifteen drops of it, add four or five drops of alcohol and a fragment of sodium; a brown deposit, approaching black, in proportion as the nitro-benzol is in excess, occurs. This reaction is instantaneous, and when the oil contains from 30 to 50 per cent. of nitro-benzol one minute is sufficient to obtain a thick brown liquid.

Indestructible Writing.—Lucas proposes for this purpose an ink composed of 20 grains of sugar dissolved in 30 grains of water, to which is added a few drops of concentrated sulphuric acid. Upon heating this mixture the sugar becomes carbonised, and when applied to the paper leaves a coating of carbon which cannot be washed off. This stain is rendered more permanent by the decomposing action of the acid itself upon the paper, and thus made, it resists the action of chemical agents. The paper should, after drying, be passed through a weak alkaline solution to remove excess of acid.

On a New Falsification of Saffron, by M. Guibourt.—M. Vesque, pharmacien of Lizieux, from a house in Paris, under the name of *Safran du Gatanais*, 250 grammes of a saffron of inferior quality, containing about 30 per cent. of a material judged to be the stamens. Professor Decaisne, who has examined this substance, has recognised in the length of the filaments the cylindrical form of the anthers and the large size of the pollen grains, that these stamens are those of a *Crocus*. But they are not the stamens of the mother plant, which have been inadvertently collected with the stigmata, the colour of which is yellow and easily distinguishable. They are evidently collected intentionally, dyed artificially, and twisted so as to deceive the eye, and in quantity equal to nearly a half of the article. The adulteration is recognised by throwing a certain quantity into a glass of water. The stamens are instantly decolorised and float, whilst the true stigmata fall to the bottom of the water. On comparison with the figures of Hayne, these stamens belong to the *Crocus vernus*, by the cylindrical form of their anthers, rounded at the summit, whilst the anthers of *Crocus sativus* are terminated like an arrow. Finally, this saffron contains also little marigold petals, coloured red like the stamens; these sink in water with the stigmas of the saffron, and are recognised by their base, their longitudinal nervures, and three pointed terminations.

On Commercial Bromide of Potassium, by W. T. Fewtrell.—The use of bromide of potassium as a remedial agent has of late greatly increased, and it is now administered in very large doses. Recently it has been observed that the use of the remedy has been occasionally followed by symptoms of *iodism*, or the peculiar affections which are sometimes produced by excessive doses of iodine or iodide of potassium. As no such effects have been observed to follow the exhibition of bromide of potassium, the circumstance gave rise to a suspicion that some specimens of the bromide are adulterated (the present difference in the price of bromine and iodine justifies this term) with iodide of potassium. I accordingly procured a sample of the salt for examination. It was labelled "Bromide of Potassium (French)." It was a well crystallised salt, the crystals being perhaps rather more opaque than those of the pure bromide. A qualitative examination at once revealed the presence of a considerable proportion of iodine; and quantitative analysis showed that the amount present corresponded to 20 per cent. of iodide of potassium. This adulteration deserves the serious attention of pharmacentists and medical men, who will do well to test all samples of bromide they receive. A solution of the salt mixed with a little mucilage of starch should not exhibit any blue colour on the addition of solution of chlorine.

Manufacture of Aluminium.—The alkaline metals have hitherto been considered the only agents for reducing the chlorides of aluminium, but Mr. N. Basset, of Paris, has discovered that the metalloids and metals which by double decomposition will form chlorides more fusible and volatile than the chlorides of aluminium may be employed for reducing these latter. For instance—arsenic, boron, cyanogen, zinc, antimony, mercury, and even tin, may be used, and also the amalgams of zinc, antimony, and tin. The inventor prefers to use zinc, owing to its low price, its facility of application, its volatility, and other useful properties. The zinc should always be added in excess in the proportion of, say, four of zinc to one of chloride of aluminium. When this latter is brought into the presence of zinc at a temperature of from 250° to 300° centigrade, a chloride of zinc and free aluminium is obtained. This latter will dissolve in the excess of zinc, and the chloride of zinc combining with the chloride of sodium, the mass becomes thick or pasty, and then solid, while the alloy of zinc and aluminium remains liquid. If the temperature of the mass is again raised it all becomes liquid again, and the zinc reduces another portion of chloride, and the excess of zinc becomes enriched with an extra quantity of aluminium. The rich alloy is again melted with the addition of more chloride of aluminium, and kept well stirred or agitated, until nearly pure aluminium, with only a small per centage of zinc, is obtained. This is again melted at nearly a white heat, until the remaining zinc is volatilised, and pure aluminium remains.

Minium of Iron.—The society called the *Académie Nationale*, of Paris, has awarded a medal to M. de Cartier, for his preparation of *Minium de fer d'Anderghem*—the name of the place of manufacture in Belgium. The *Société d'Encouragement*, and the *Société Centrale des Architectes*, also of Paris, have likewise reported favourably on the product. The minium of iron is said to answer all the purposes of white lead, and other preparations of the like kind for painting, and to possess more solidity, to be cheaper, to last longer, and to have an especial value in preserving iron from oxidation, and rendering the surface of wood hard. Remarkable freedom from acid or adulteration is claimed for M. de Cartier's product, which is also said to lie on iron surfaces evenly and smooth like a varnish, effectually excluding air. It is in use on the Belgian railways and steam boats, and also in the army and the prisons; and it is recommended for dressing canvas for awnings, tarpaulings, and other protecting sheets. It works with linseed boiled oil, like any other pigment, or with cold oil with the addition of a little dryer such as litharge, but not turpentine; but for painting iron, to be exposed to sea water, litharge must not be used. It must be mentioned, however, that it is of a dark brown colour; but its tone may be changed by the addition of black, yellow, or green. Its durability is said to be two or three times greater than that of white lead. It will bear a great amount of heat, and, mixed with tar, forms an excellent pigment for boats, hardening the wood in a remarkable manner. When mixed with oil it does not separate again like white lead, or become clotted. The following are the proportions given for its use: a kilogramme of minium, with 1½ kil. of oil, and 1-20th kil. of dryer.

LIST OF APPLICATIONS FOR LETTERS PATENT.

"We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent, Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of The Artizan."

Dated October 25th, 1864.

2636 J. Heap & T. Jolley—Measuring clay
2637 H. E. Craven & T. Carrack—Cutting out the soles of boots
2638 J. Tate—Signalling on railways
2639 R. A. Brooman—Furnaces
2640 S. Shaw—Looms for weaving
2641 E. H. Taylor—Emptying the contents of casks and other vessels
2642 G. E. Donisthorpe—Combing wool and other fibres
2643 E. B. Wilson—Fire-places
2644 W. Clark—Rotary engines

Dated October 26th, 1864.

2645 J. Dannant—Preventing the fouling of ships, bottoms
2646 P. Dutrulle—Syrups
2647 R. W. Wilton—Construction of roofs
2648 J. E. F. Ludeke & D. Wilckens—Motive power by capillary attraction
2649 J. Hall, W. Dunkerley, & S. Schofield—Preparing cotton
2650 B. F Brunel—Treating tetanic iron sands
2651 F. Jenner—Purses, bags, and other similar receptacles
2652 J. Cunningham & R. Cunningham—Weaving ornamental fabrics
2653 J Nimmo—Distilling oils
2654 R. Hart—Preparing jute
2655 P. A. Le Comte de Fontainemoreau—Spectacle frames
2656 P. A. Le Comte de Fontainemoreau—Uniting iron with wood
2657 J. Walmsley & N. G. Pitman—Cord
2658 C. May—Lock fastenings for smelling and other bottles

Dated October 27th, 1864.

2659 N. N. L. Lonsdale—Regulating the flow of oil for lubricating purposes
2660 J. Shelmerdine—Cotton gins
2661 J. Stobo & W. Pollock—Wringing yarns
2662 J. Craven & S. Fox—Railway rolling stock and traction engines
2663 W. Cougalton—Fitting sails to ships
2664 E. J. W. Parnacott—Artificial stone
2665 R. A. Brooman—Sextants

Dated October 28th, 1864.

2666 D. Laidlaw & J. Robertson—Heating, cooling, and applying aeriform bodies
2667 W. Jackson—Sewing machines for using shoemaker's wax thread
2668 J. Charlton, H. Charlton. & J O. Christian—Rendering non inflammable fibrous materials
2669 J. P. Harriss—Fire-arms and projectiles
2670 W. Dowley—Communication between passengers and engine driver
2671 J. Goodall & P. Goodall—Brushes
2672 G. Ager—Protecting ships' bottoms
2673 W. Cormack—Distillation of solid matters
2674 G. Rydill—Hydraulic engines
2675 A. Parkes—Materials for waterproofing
2676 J. Hartshorn & J. Gadsby—Lace in twist lace machines
2677 H. A. Jowett, J. E. Jowett, & J. B. Muschamp—Permanent way of railways

Dated October 29th, 1864.

2678 A. Smith & W. Smith—Centrifugal apparatus
2679 J. L. Davies—Shaping metallic articles
2680 A. H. A. Durant & W. H. P. Gore—Materials for panels
2681 L. P. G. Bellet & C. M. Philippe de Rouvre—Electricity as a motive power
2682 W Clark—Bolts or fastenings,
2683 H. Larkin—Hooks
2684 B. R. Keith—Farinaceous food
2685 J. L. Norton—Drying fabrics
2686 G. H. Devereux—Syphons

Dated October 31st, 1864.

2687 J. H. Simpson—Electric printing for telegraphic and other purposes
2688 C. O. Crosby—Fish hooks
2689 B Scale—Mounting chamber utensils
2690 J. Solomon & A. G. Grant—Lamps for burning magnesium
2691 G. Davies—Warming and cooling railway carriages
2692 J. M. Rowan—Presses for expressing fluids
2693 N. F. Andreasen—Distributing liquid manure and sowing seed
2694 E. Edwards—Mixing and kneading dough

Dated November 1st, 1864.

2695 J. F. Brinjes—Reburning animal charcoal
2696 P. L. Charon—Fire-places
2697 W. Moody—Stringing and tuning pianofortes
2698 W. E. Gedge—Axle
2699 T. Ivory—Steam engines, boilers, and condensers for the same
2700 P. A. Roger—Preventing the extinction of lamps
2701 W. Rice—Wheels and axles of railway and other carriages
2702 I. Schwartz—Lighting rooms
2703 W. Aston—Buttons

Dated November 2nd, 1864.

2704 W. Smith—Tanning leather
2705 R. Richardson—Covering horses
2706 J. Forster—Paper
2807 G. Ashcroft—Presses for pressing fibrous substances
2708 J. Furnevall & G. Keighley—Combining railway wheels and axles
2709 E. Pilkington—Waterproof fabrics
2710 R. C. Robinson—Semaphoric signals for railway carriages
2711 J. Drury—Steam engines
2712 J. F. Scott—Signalling between passengers and guards
2713 J. Walker—Signals in carriages
2714 E. L. S. Benzon—Casting steel
2715 C. W. Wardle & R. McIntyre—Drilling metallic substances

Dated November 3rd, 1864.

2716 W. Davies, G. Cate, & W. Cate—Cutting corks and similar articles
2717 T. Fox—Photographic process
2718 S. Davies—Thrashing machines
2719 C. Garton & T. Hill—Fermenting and bottling ale and wine
2720 E. T. Hughes—Coverings for the head
2721 W. Newoould—Ascertaining the amount of money received by conductors
2722 E. G. Brewer—Inkstands
2723—H. W. Spencer & J. E. Ball—Glue and size
2724 J. G. Rowe—Safety apparatus applicable to railway trains
2725 J. Cutler—Waste pipes of cisterns
2726 W. Baylis—Punching metals
2727 J. C. Brant—Lighting carriages

Dated November 4th, 1864.

2728 E. J. Harrison—Handles of carriage doors
2729 J. Dodge—Files
2730 N. B Harris & J. P. Thomson—Cigars
2731 F. S. Gilbert—Screw driving
2732 F. L. Bauwen—Cooking food
2733 F. Yates—Steel and iron
2734 F. Yates—Generating gases
2735 H. A. Gwynne—Centrifugal pumps
2736 A J. Fraser—Marking vamps or toecaps of boots
2737 R. K. Bowley & K. T. Bowley—Spurs
2738 T. P. W. Boulton—Obtaining motive power from aeriform fluids
2739 T. N. Kirkham, V. F. Ensun, & H. Brook—Drying woven fabrics

Dated November 5th, 1864.

2740 J. Sullivan—Oil lamps
2741 J. Snider—Breech-loading fire-arms
2742 J. R. Crompton—Embossing paper
2743 D. Ellis & M. Hulas—Weaving fabrics
2744 M. J. Roberts—Sprinkling liquids over cloth
2745 H. V. Scatterwood—Cotton gins
2746 G. Haseltine—Fastening rivets

Dated November 7th, 1864.

2747 J. D. Young—Rolled iron railway bars or metals
2748 A. Estnourneaux & L. Beauchamps—Non-conducting composition
2749 F. H. Bickes—Distilling
2750 G. Duncan—Printing machines
2751 W. Thrift—Rotary engine
2752 D. Cullen—Manufacture of oakum
2753 G. Simpson—Preventing accidents on railways
2754 A. Steven—Hydraulic presses
2755 W. E. Gedge—Cleansing grain
2756 R. A. Brooman—Packing for stuffing boxes
2757 J. Slack—Filtering apparatus
2758 J. M. Stanley & J Stanley—Blowing furnaces
2759 W. E. Newton & E. C. Shepard—Breech-loading fire-arms
2760 A. V. Newton—Hooped skirts
2761 C. T. Burgess—Centrifugal pumps
2762 A. Field—Night lights
2763 G. P. Harding & Thomas—Fire-arms

Dated November 8th, 1864.

2764 W. B. Adams—Diminishing the wear on railways
2765 R. Montague—Holding the cords of window blinds
2766 R. Rimmer—Drawing off liquids
2767 J. Henshaw—Giving alarm on railways
2768 J. Hurt & H. Tonge—Grinding corn
2769 L. C. Meaulle—Stamping machine
2770 C. Garton—Obtaining power from liquids
2771 W. K. Hall—Raising screw propellers
2772 A. Bechem & H. Wadekind—Rolling metals
2773 J. H. Johnson—Yarns and threads
2774 J. Okey—Boots and shoes
2775 J. Bell—Smoky chimneys
2776 A. Moreau—Extracting silver from lead
2777 S. Rydbeck—Breech-loading fire-arms

Dated November 9th, 1864.

2778 J. D. Welch & A. P. Welch—Strengthening brims of straw hats
2779 G. B. Galloway—Preventing boiler explosions
2780 S. Dixon—Paper file
2781 J. Robinson—Navigable vessels
2782 S. C. Reed—Traps for drains
2783 J. Rae—Conveying sea water to inland places
2784 J. Thompson—Ordnance
2785 J. Dale, H. Caro, & C. A. Martins—Colouring matters for dyeing
2786 W. E. Newton—Filter press

Dated November 10th, 1864.

2787 F. Lana—Bottle stopper
2788 J. A. Manning—Treatment of night soil
2789 J. Robinson and J. Cresham—Raising fluids
2790 R B. Cooley—Coverings for the head
2791 M. A. F. Mennons—Shades for lighting apparatus
2792 M. W. Ruthven—Steering apparatus
2793 E. J. W. Parnacott—Sharpening saws
2794 J. McCall and B. G Sloper—Preserving meat
2795 T. L. Boote and R. Boote—Pottery
2796 J. Simes—Steam and other engines
2797 H. Brockett—Permanent way of railways
2798 L. Cooke—Manufacture of paper

Dated November 11th, 1864.

2799 G. A. Henty—Torpedo rams
2801 W. Willis—Reproducing by the agency of light printed documents
2801 W. L. Lees—Joining substances
2802 G. Dixon—Crushing sugar
2803 W. Clark—Generating motive power
2804 W. Clark—Looms
2805 J. Cockshott—Cleaning forks and spoons
2806 G Smith—Drying materials
2807 J. Kinniburgh—Moulds for casting
2808 W. E. Gedge—Sanitary toilet apparatus
2809 F. Fearon—Deadening sound
2810 W. E. Gedge—Moulds for casting
2811 M. C. Thurgar and R. A. Ward—Developing heat
2812 C. Mohr and S. E. Smith—Cages for birds and animals
2813 E. Richardson—Fog signals
2814 C. W. Heckethorn—Working ships' pumps, and preventing vessels foundering
2815 J. Thorne—Washing machines
2816 D. S. Sutherland—Compressing gunpowder for blasting purpposes
2817 J. Keats and W. S. Clark—Sewing machines

Dated November 12th, 1864.

2818 G. Davies—Knapsack supporter
2819 C. Martin—Opening and closing the heads of carriages
2820 W. Fisher—Securing envelopes
2821 F. A Papps—Malt liquors as tonics
2822 J. McCluskey—Sewing machines
2823 C. S. Cadinau—Whips, umbrellas, and walking sticks
2824 E. F. Woods and J. S. Cocksedge—Feeding millstones
2825 H. W. Ripley—Preparing wool and hair for yarns
2826 C. Cotton and W. Nuon—Communication between passengers and guards
2827 C. Esplin—Regulating the supply of gas
2828 T. Jones—Heating water
2829 P. A Le Comte de Fontainemoreau—Looms for weaving
2830 W. E. Gedge—Pumps

Dated November 14th, 1864.

2831 G. Bell and R. Luthy—Producing flawless castings
2832 G. E. Noose—Deodorising and utilising the sewage of towns
2833 G Needham—Ladies' dresses
2834 R. Gardner—Boilers for brewing
2835 J Farrar and J. Farrar—Covering for carding substances
2836 R. Harlow and W. Jolley—Valves
2837 J. M. Hart and R. Purkis—Lubricating carriage axles
2838 C. L. Oliver—Brushing the hair
2839 J Firth—Steel
2840 J. J. Renons-Cere—Manure
2841 T. F. Vickers—Steel castings
2842 M. Henry—Treating bodily injuries and disorders
2843 N. Bailly and C. Durand, G. H. Mesoard, and Z. Poirier—Rolling friction

Dated November 15th, 1864.

2844 A. C. Henderson—Storing grain
2845 G. Robinson—Casting pipes
2846 J. J. Moutie—Treating benzole or its principal composing hydro-carbons
2847 G. C. Attree—Scarfs for the neck
2848 P. Lachez—Looms for weaving carpets and other pile fabrics
2849 J N. Smith—Crinoline skirts
2850 J. Bullough—Looms for weaving
2851 C. Vero—Hats
2852 A. Wall—Combination of materials to be used as fuel
2853 J. P. Nolan—Cooling projectiles from the interior
2854 J. Rowley—Printer's ink
2855 T. Restell—Breech-loading fire-arms
2856 S. C. Kreeft—Iron and steel

Dated November 16th, 1864.

2857 R. Holiday—Securing the levers used to work railway signals
2858 M. Destrem—Composition for painting
2859 R Atkinson and H. Lea—Machinery for grinding files
2860 J. Gothard and H. Garland—Fire bars
2861 F. C Parker—Preparation of jute and other fibrous substances
2862 J Aubin—Millstone for grinding corn and other substances
2863 W. E. Newton—Printing machinery
2864 W. E Newton—Soda
2865 H. Grafton—Shutters
2866 J. Hughes—Cylinders
2867 H. Grafton—Machinery for cutting wood into mouldings

Dated November 17th, 1864.

2868 G. Score and R. W. Sievier—Communication between passengers and guard
2869 R. G. Grimes—Arrangement of the cases of beer engines
2870 J. Sheppard—Protection of valuables worn on the person
2871 T. Rowatt—Lamps for burning hydro-carbon fluids
2872 J. H. Johnson—Manufacture of gold leaf and other metal foils
2873 G. T. Bousfield—Manufacture of ornamental chains
2874 H. Wilson—Boring holes in sleepers for railways
2875 H. Wilson—Planing wood
2876 A. G. Hunter—Soda and potash

Dated November 18th, 1864.

2877 J. Fisher—Furnaces used for the manufacture of iron tubes
2878 S. Sharp—Ships' anchors
2879 W Snell—Machinery for the manufacture of bricks
2880 J. Behrends—Apparatus for raising and drawing off liquids
2881 W. Sargeant—Horse hoes and seed or other drills
2882 T. A. Blakely—Working guns
2883 A. A. Croll—Materials to be used in the purification of gas
2884 M. Henry—Carbonising wood and performing other operations in which substances are treated by heat
2885 W. Clark—Weighing balances
2886 J. Webster and J. Laugham—Knitted or looped fabrics
2887 W. Wilson—Improvements in the manufacture of hats
2888 J. Petrie—Valves for regulating the flow of steam in steam engines
2889 S. Piesse—Apparatus for creating and projecting cold vapours
2890 E. S. Jones—Motive power for the propulsion of ships

Dated November 19th, 1864.

2891 J. Phillips—Prevention of steam boiler accident
2892 J. G. Tongue—Fire-arms, and in cartridges for the same
2893 A. H. Stott—Boilers
2894 W. V. Wilson and J. Wanklyn—Purple dye-stuffs
2895 J. Pitman—Instrument for determining latitude and longitude
2896 J. Easton—Apparatus for the manufacture of paper pulp
2897 J. Gaukroger and A. Gaukroger—Looms for weaving
2898 W. Palmer—Improved cases for carrying pipes and tobacco

Dated November 21st, 1864.

2899 J. Macintosh and A. H. Thurgar—Propelling ships
2900 T. W. Panton and H. Panton—A machine for machining the ends of butts of bent iron plates causing them to fit with accuracy
2901 W. E. Newton—Fire-places for heating apartments
2902 W. Martin—Sewing machines
2903 H. Willis and G. Rice—Sewing machines, and in winders for the same
2904 J. Griffiths—Machinery used in the manufacture of steel
2905 S Bourne—Valves for regulating the passage of air or gas

Dated November 22nd, 1864.

2906 A. V. Newton—Sugar
2907 J Leetch—Breech-loading fire-arms and ammunition
2908 H. Eckersley—Weaving piled fabrics termed satteens
2909 J. Wylie and J Rew—Impressed gold paper hangings
2910 G. Kottgen—Pockets, also applicable to the manufacture of bags
2911 H. I. Mnquet—Stamping or pressing in colors and otherwise
2912 J. Snider—Breech-loading fire-arms
2913 W. Ibotson—Preparation of pulp for the manufacture of paper
2914 P. E. Guy—Excavating and cutting rock and stone
2915 T. Shorey and G. Gibson—Reefing and furling sails
2916 J. C. L. Durand—Manufacture of colouring matter
2917 R. Morrison—Steam hammers, anvil blocks, and their foundations
2918 T. M. Brisbane—Power engine to be worked by steam

Dated November 23rd, 1864.

2919 N. Hodgson—Washing and mangling
2920 G. M. de Bayelt and J. E. Vigoulete—Compounding artificial fuel
2921 P. Garnett—Scribbling fibrous substances
2922 J. Paley and T. Rawsthorne—Mules for spinning
2923 F. Millns—Cooling liquids
2924 S Price—Lifting window sashes
2925 G Prioleau—Releasing horses from carriages
2926 J. S. Gisborne—Transmission of motion from one place to another
2927 F Pfanbauser—Tanning
2928 R. Oberdoerffer—Cigar holders
2929 P. Haggie and P. Gledhill—Machinery employed in getting coal
2930 G. Brunton—Polishing

Dated November 24th, 1864.

2931 E. Molyneux—Railways
2932 J. Kissack—Ventilating
2933 J. Eastwood and W. Wadsworth—Finishing cotton pieces
2934 F. Sang—Cupola chandelier
2935 R. Wheeble—Communication between passengers and guard
2936 T. Perkins—Washing coprolites
2937 J. White—Purifying atmospheric air
2938 W. Keiller—Preparation of marmalade
2939 W. Ryder—Burning paraffin
2940 L. Valaut—Feeding steam boilers
2941 P. E. Gaffe and E. Zglinicke—Engraving apparatus
2942 E. Cottam—Hydraulic presses
2943 R. A. Brooman—Lighting cigars
2944 W. Clark—Ornamentation of feathers
945 C. H. Crompton-Roberts—Treatment of drying oils and varnishes